Geo Duffield

Geo Dudley

Carlisle Institute

1830

Recitation on M. Lectures
on Friday After

Recitation on Minutes
Friday Afternoon

Geo Duffield
Carlisle

G DUFFIELD

[illegible]

1757 2

A

NEW TREATISE

George ON THE Duffield

USE OF THE GLOBES,

WITH

NOTES AND OBSERVATIONS,

CONTAINING AN

EXTENSIVE COLLECTION OF THE MOST USEFUL

PROBLEMS,

Illustrated by a suitable variety of Examples.

George DESIGNED FOR Duffield

THE USE OF SCHOOLS AND ACADEMIES.

BY JAMES M'INTIRE.

SECOND EDITION.

REVISED, CORRECTED AND IMPROVED.

Baltimore:
PUBLISHED BY E. J. COALE.
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1826.

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Tappan Presb. Ass
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RECOMMENDATIONS.

Baltimore, Jan. 11, 1823.

Dear Sir,

I have glanced over the sheets of your new Treatise on the Use of the Globes, and am free to declare, that I think it the best suited to the use of Schools and Academies of any I have seen. It appears brief without defect, and copious without redundance. If my recommendation be of any worth, it is heartily at your service.

JAMES GRAY, D. D.

Mr. James M'Intire.

Baltimore, Jan. 13, 1823.

Sir,

I have examined with pleasure and interest, your Treatise on the Use of the Globes, and am of opinion, that, by confining yourself to such matter as immediately concerns that subject, and omitting to treat like some other writers on this subject, of Astronomy, Natural Philosophy, and things extraneous thereto, your Treatise is more concise, cheap, and better adapted for the use of schools. Hoping that you may meet with that recompense, which your useful labours appear to merit,

I am,

Your friend and obedient servant,

JOHN ALLEN,

Prof. of Math. in the University of Maryland.

Mr. James M'Intire.

Baltimore, Jan. 15, 1823.

Dear Sir,

Upon a careful perusal of your new Treatise on the Use of the Globes, I think that it is better suited for the instruction of youth in that useful and interesting subject, than any other that has come under my inspection. You have been peculiarly concise in the language of your definitions, and without rendering them less obscure, you have obviated the difficulty that young beginners generally meet in studying more voluminous treatises. Your selections of problems is well adapted to inspire youth with a preper taste for pursuing the study of Astronomy, in its most extended form; and as you have inserted nothing but what is really connected with the use of the Globes, I think your book will be more portable, and useful, and studied with more pleasure and delight than any heretofore published on the same subject.

Dear Sir, wishing you every success in your undertaking, I remain with the greatest respect, your sincere friend.

OWEN REYNOLDS,
Prof. Math. Baltimore College.

Mr. James M'Intire.

Baltimore, Jan. 15, 1822.

Sir,

I have examined your new Treatise on the Use of the Globes, and am much pleased with it. The books that I have seen on this subject are, for the most part either filled up with matter which has no immediate connexion with the main subject, and thereby their price is increased, or they are too concise, and consequently unfit for giving a sufficient knowledge of the subject. Your treatise lies between these extremes, the problems are well chosen, the rules clear and concise, and the examples appropriate. Upon the whole, I think it the best school book of the kind with which I am acquainted.

JAMES JOHNSTON,
Teacher of Math. Baltimore.

Mr. James M'Intire.

ADVERTISEMENT

TO THE SECOND EDITION.

The reception given to the first impression of this work has surpassed the most sanguine hopes of its author. He therefore offers to a discerning public a second edition.

Some additional matter is now introduced, which will be found useful to the young student; particularly the notes attached to the Solar System, in which the distances and magnitudes of the planets are truly calculated. This edition is also embellished with three plates, illustrative of some of the most important branches of Astronomy, which will prove not only amusing, but very instructive to the learner.

Baltimore College, November, 1826.

PREFACE.

The general extension of navigation and commerce over our globe, the numerous voyages of discovery which have characterized the last century and the present, the number of travellers who have traversed the earth in all directions in pursuit of philosphical and political knowledge, the multiplying labours of christian missionaries, the restlessness of inflamed curiosity, and even the wars, invasions, and revolutions of our eventful age, have all co-operated to bring the different tribes of the human family acquainted with each other, and in a certain degree have united them all into one society The learned men of this age, are better acquainted with the whole of our globe, than their predecessors a few centuries back were with their respective native countries.

Hence it has been found necessary to enlarge the system of school-education, and to allow a liberal space to the subject of physical, political and religious geography. We have been led into this course not merely by the desire of gratifying a liberal curiosity, but by the necessity of qualifying men for the discharge of the various duties of life. The philosopher, the theologian, the physician, the politician, the merchant, are all at present obliged to collect the materials of sound conclusions from every quarter of the globe. Even well educated females are expected to have added a competent share of geographical knowledge to the other accomplishments of their sex.

Therefore in all our schools, male and female, geography is becoming a favourite study. It need not be remarked that an acquaintane with the use of the globes is essential to the knowledge of geography; but we may

be allowed to say that it has the additional advantage of opening to youthful minds a view of the beautiful visions of planetary motion, and of the other charms of astronomy, which never fail to inspire rapturous feelings of delight, and to create a genuine taste for the beauties and sublimities of nature.

A treatise on the use of the globes calculated for the use of schools seems to be wanted. The small compends which are commonly met with, are too puerile and trifling, and in every view incompetent to the attainment of their object. The works of Keith and Wallace on the globes are masterly productions, beyond all praise; but they are manifestly better suited for the higher classes of learners than for beginners. They pursue astronomical studies beyond the capacities of youth in general, and the systems of natural philosophy which they have introduced, are still more objectional, as they have no immediate connexion with the main subject. They are excellent books but not exactly that sort of books which were most generally wanted, as no teacher will ever think of carrying a class unacquainted with the rudiments of mathematics, (with any degree of satisfaction to himself,) through them.

The design of the author in the present effort, is to produce a work on the use of the globes suited to the exigencies of school instruction; to supply on the one hand the defects of the smaller compends, and on the other to convey to the pupil a comprehensive knowledge of the subject without introducing the superfluous matter and details with which the larger works abound. With what degree of judgment this attempt has been made the public will determine, against whose judgment there is no appeal; but it is hoped that they will receive with indulgence a well meant attempt to simplify the system of education, and thus promote the diffusion of useful knowledge.

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ASTRONOMICAL DEFINITIONS.

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A

NEW TREATISE

ON THE

USE OF THE GLOBES.

DEFINITIONS.

1. The *Terrestrial Globe* is an artificial representation of the earth; having the four quarters of the world, the different empires, kingdoms, countries and states; the several oceans, seas and principal rivers; the chief cities, towns, &c. truly delineated on its surface, according to their relative situation on the earth.

2. The *Celestial Globe* is an artificial representation of the heavens; having the fixed stars laid down on its surface, according to their natural order in the heavens. The student must suppose himself placed in the centre of this globe, and viewing the stars in the concave surface.

3. The *Axis of the Earth* is an imaginary line passing through its centre, on which it revolves; and is represented by the wire that passes through the centre of the artificial globe from north to south.

4. The *Poles of the Earth* are those two points, where the axis is supposed to cut its surface; the one

is called the north, or arctic pole; and the other the south, or antarctic pole. The celestial poles are two imaginary points in the heavens exactly above the poles of the earth.

5. *Great Circles* divide the globe into two equal parts.

6. *Small Circles* divide the globe into two unequal parts.

7. The *Brass Meridian* is a great circle which divides the globe into the eastern and western hemispheres, and in which the globe revolves. It is divided into 360 equal parts, called degrees.* The degrees in the upper semicircle of the brass meridian, are numbered from the equator towards the poles; and those in the lower semicircle, are numbered from the poles towards the equator.

8. *Meridians* are semicircles cutting the equator at right angles, and extending from pole to pole. Every place on the globe is supposed to have a meridian passing through it. When the sun comes to the meridian of any place, (not within the polar circles,) it is noon at that place.

9. The *First Meridian* is that from which the longitudes of places begin to be reckon, and passes through some noted place. In English globes, the first meridian is supposed to pass through London, or the Royal Observatory at Greenwich.

10. The *Equator* is a great circle of the earth, situated at an equal distance from the poles, and dividing the globe into two hemispheres, the northern and southern. The equator, when referred to the heavens, is called the equinoctial, because when the sun comes to it, the days and nights are equal all over the world.

11. The *Ecliptic* is the path which the earth describes in revolving round the sun; or it is that apparent circle, which the sun describes by his annual progress in the heavens. The ecliptic cuts the equator in an

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*The circumference of every circle is supposed to be divided into 360 equal parts, called degrees; each degree into sixty equal parts, called minutes; each minute into sixty equal parts, called seconds; and so on.

angle of 23° 28′; the points of intersection are called the equinoctial points.

12. The *Zodiac* is a zone or belt, which extends about 8 degrees on each side of the ecliptic on the celestial globe, and contains the orbits of all the planets.*

13. *Signs of the Ecliptic.* The ecliptic and zodiac are divided into 12 equal parts, called signs, each containing 30 degrees. The names and characters of the signs, with the days on which the sun enters them, are as follows.

Northern Signs.

Spring.	♈	Aries, *the Ram,* 20th of March.
	♉	Taurus, *the Bull,* 19th of April.
	♊	Gemini, *the Twins,* 20th of May.
Summer.	♋	Cancer, *the Crab,* 21st of June.
	♌	Leo, *the Lion,* 22nd of July.
	♍	Virgo, *the Virgin,* 22nd of August.

Southern Signs.

Autumn.	♎	Libra, *the Balance,* 23d of September.
	♏	Scorpio, *the Scorpion,* 23d of October.
	♐	Sagittarius, *the Archer,* 22d of November.
Winter.	♑	Capricornus, *the Goat,* 21st of December.
	♒	Aquarius, *the Water-bearer,* 20th January.
	♓	Pisces, *the Fishes,* 19th of February.

14. The *Horizon* is a great circle, separating the visible half of the heavens from the invisible; and when referred to the earth, it is distinguished by the sensible, or visible and rational horizon.

* Except the new planets, or Asteroids, Ceres and Pallas.

15. The *Sensible* or *Visible Horizon*, is that circle which terminates our view in a clear day, where the earth, or sea, and the sky seem to meet.

16. The *Rational*, or *True Horizon*, is a plane supposed to pass through the centre of the earth, parallel to the visible horizon.

17. The *Wooden Horizon*, which circumscribes the artificial globe, is a representation of the rational horizon. It is divided into several concentric circles. On Cary's globes these circles are arranged as follows.

The first circle is divided into degrees, and is num- from 0 to 90 degrees, from the east towards the north and south, and in the same manner from the west towards the north and south.

The second circle contains the 32 points of the compass.

The third circle contains the 12 signs of the zodiac, with the figure and character of each sign.

The fourth circle contains the degrees of the signs, each sign comprehending 30 degrees.

The fifth circle contains the days of the month, answering to each degree of the sun's place in the ecliptic.

The sixth circle contains the 12 calendar months of the year.*

18. The *Tropics* are two small circles, each parallel to the equator, and at the distance of 23° 28′ from it. The northern is called the tropic of Cancer, and the southern, the tropic of Capricorn.

19. The *Polar Circles* are two small circles, parallel to the equator, and at the distance of 23° 28′ from each pole. The northern is called the arctic, and the southern the antarctic circle.

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* On Bardin's new British Globes, there is a circle containing the equation of time. When the clock ought to be faster than apparent time, the number of minutes showing the difference. is marked by the sign +; and when the clock ought to be slower, the number of minutes expressing the difference, is marked by the sign —.

20. *Parallels of Latitude* are small circles parallel to the equator. Every place on the globe is supposed to have a parallel of latitude drawn through it, though they are only drawn through every 10 degrees of latitude on the terrestrial globe.

21 The *Hour Circle* is a small circle of brass fixed to the north pole, and divided into 24 equal parts, correspondent to the hours of the day, each part is again subdivided into halves and quarters.

22. The *Mariner's Compass* is a representation of the horizon, and consists of a circular card, divided into 32 points, each containing 11° 15′, which is placed on a magnetical needle, that always points towards the north. By means of the mariner's compass ships at sea are directed in their course, and the bearin g of distant objects ascertained.

23. The *Variation of the Compass* is the deviation of the needle's point from the true north point of the horizon, and is either east or west.

24. The *Quadrant of Altitude* is a thin slip of brass, divided on one edge from 0 upwards to 90 degrees, and from 0 downwards to 18 degrees, corresponding to as many degrees on the equator. The quadrant of altitude, when used, is generally screwed on the brass meridian.

25. The *Cardinal Points of the Horizon* are east, west, north, and south.

26 The *Cardinal Points in the Heavens* are the zenith and the nadir.

27. The *Cardinal Points of the Ecliptic* are the equinoctial and solstitial points.

28. The *Zenith* is an imaginary point in the heavens exactly over our heads.

29. The *Nadir* is an imaginary point in the heavens exactly under our feet.

30. The *Pole of a Great Circle* is a point on the surface of the globe, equidistant from every part of that

circle of which it is a pole. Every great circle has two poles diametrically opposite to each other.

31. The *Equinoctial Points* are Aries and Libra, where the equinoctial is cut by the ecliptic. The point Aries is called the vernal equinox, and the point Libra the autumnal equinox.

32. The *Solstitial Points* are Cancer and Capricorn. When the sun enters these points, his declination is the greatest possible.

33. The *Declination of the Sun, a Star*, or *Planet*, is its distance from the equinoctial, northward or southward. When the sun enters the signs Aries and Libra, he has no declination, being then in the equinoctial. The greatest declination which the sun can have, is 23° 28′, and that of a star 90°, north or south.

34. The *Latitude of a Place* is its distance in degrees from the equator, reckoned on the brass meridian towards the north or south pole. The greatest latitude that a place can have, is 90 degrees.

35. The *Latitude of a Star or Planet* on the celestial globe, is its distance in degrees from the ecliptic, reckoned on the quadrant of altitude towards the north or south pole of the ecliptic. The sun being always in the ecliptic, has no latitude.

36. The *Longitude of a Place* is the distance of its meridian from the first meridian, reckoned in degrees on the equator, and is either east or west. The greatest longitude that a place can have, is 180 degrees.

37. The *Longitude of a Star or Planet* is reckoned on the ecliptic from the point Aries, eastward, round the celestial globe. The longitude of the sun is what is called his place in the ecliptic.

38. The *Difference of Latitude* between two places, is an arc of a meridian, contained between the parallels of latitude of the two places, and cannot exceed 180 degrees.

39. The *Difference of Longitude* between two places, is an arc of the equator, intercepted between the meri-

dians of the two places, and cannot exceed 180 degrees.

40. *Parallels of Celestial Latitude* are small circles on the celestial globe, parallel to the ecliptic.

41. The *Colures* are two great circles passing through the poles of the celestial globe; one of which passes through the equinoctial points, and the other through the solstitial points; hence they are called the equinoctial and solstitial colures.

42. *Azimuth*, or *Verticle Circles*, are great circles supposed to pass through the zenith and the nadir, cutting the horizon at right angles.

43. The *Altitude* of any object in the heavens, is an arc of a vertical circle, contained between the centre of the object and the horizon. When the object is on the meridian, its altitude is called the meridian altitude.

44. The *Azimuth* of any object in the heavens, is an arc of the horizon, contained between a vertical circle passing through the centre of the object, and the north or south point of the horizon.

45. The *Amplitude* of any celestial object, is an arc of the horizon, contained between the centre of the object when rising or setting, and the east or west point of the horizon.

46. The *Zenith Distance* of any celestial object, is what its altitude wants of 90 degrees.

47. The *Polar Distance* of any celestial object, is what the declination of the object wants of 90 degrees.

48. *Hour Circles*, being the same as meridians, are drawn through every 15 degrees of the equator, each answering to an hour.

49. The *Culmination* of a star or planet. A star or planet is said to culminate, when it comes to the meridian of the place; its altitude at that place being then the greatest.

50. *Apparent Noon* at any place, is the time when the sun comes to the meridian of that place.

51. *True or Mean Noon* is 12 o'clock, shown by a well regulated clock.

52. The *Equation of Time* is the difference of time between true and apparent noon.

53. A *True Solar Day* is the time elapsed from the sun's leaving the meridian of any place, on any day, till he returns to the same meridian on the next day. On account of the obliquity of the ecliptic, and the irregular motion of the earth in its orbit, the true solar day sometimes exceeds, and at other times falls short of 24 hours.

54. A *Mean Solar Day* consists of 24 hours, and is measured by a regular clock or timepiece. There are in the course of the year, as many mean solar days as there are true solar days.

55. An *Astronomical Day* consists of 24 hours, and is reckoned from noon to noon; being the same in all latitudes.

56. The *Civil or Natural Day* consists of 24 hours, but begins differently in different nations In most of the European nations, and in America, the civil day begins at midnight.

57. A *Siderial Day* is the time which the earth takes to revolve once on its axis, and consists of 23 hours, 56 minutes, and 4 seconds.

58. An *Artificial Day* is the time which elapses between the sun's rising and setting, and varies in different latitudes.

59. A *Tropical Year* is the time which elapses between the sun's leaving one tropic or equinox, till he returns to it again; and consists of 365 days, 5 hours, 48 minutes, and 49 seconds.

60. A *Siderial Year* is the time which elapses between the sun's leaving any fixed star, till he returns to the same star again, and consists of 365 days, 6 hours, 9 minutes, 12 seconds; being 20 minutes, 23 seconds longer than the tropical year; hence, the sun returns to the equinox every year, before he returns to the same

point in the heavens; and consequently, the equinoctial points have a slow motion from east to west, called the precession of the equinoxes.*

61. *Positions of the Sphere* are three; right, parallel and oblique.

62. *A Right Sphere* is that position of the earth, where the equator passes through the zenith and the nadir, and cuts the horizon at right angles. The inhabitants who have a right sphere, live at the equator.

63. A *Parallel Sphere* is that position of the earth, where the equator coincides with the rational horizon, the poles being in the zenith and the nadir, and all the parallels of latitude parallel to the horizon. The inhabitants who have a parallel sphere, (if there be any) live at the poles.

64. An *Oblique Sphere* is that position of the earth, where the equator cuts the rational horizon obliquely. All inhabitants of the earth have an oblique sphere, except those who live at the equator and at the poles.

65. A *Zone* is a portion of the surface of the earth, bounded by two small circles parallel to the equator.—There are five zones, viz. one torrid, two temperate, and two frigid zones.

66. The *Torrid Zone* extends from the tropic of Cancer to the tropic of Capricorn, being 46° 56′ broad.

67. The *Two Temperate Zones* are each 43° 4′ broad. The north temperate zone extends from the tropic of Cancer to the arctic circle, and the south temperate zone, from the tropic of Capricorn to the antarctic circle.

68. The *Two Frigid Zones* are those portions of the earth's surface bounded by the polar circles. The north pole which is 23° 28′ from the arctic circle, is situated in the centre of the north frigid zone; and the south

*This retrograde motion of the equinoctial points, is found to be about 50¼ seconds of a degree in a year.

pole which is 23° 28′ from the antarctic circle, is situated in the centre of the south frigid zone.

69. *Climate* is a small portion of the surface of the earth bounded by two small circles parallel to the equator, and is of such a breadth, that the length of the longest day in the parallel nearest the pole, exceeds the length of the longest day in the parallel next the equator, by half an hour, in the torrid and temperate zones, and by one month in the frigid zones. Hence, there are 24 climates between the equator and each polar circle, and 6 between each polar circle and its pole.

70. *Antœci* are those people who live under the same meridian, and in the same degrees of latitude, but the one north and the other south latitude. They have contrary seasons of the year.

71. *Periœci* are those who live in the same parallel of latitude, but in opposite longitudes. They have the same seasons of the year, but when it is noon with the one, it is midnight with the other.

72. *Antipodes* are those inhabitants who walk feet to feet, or diametrically opposite to each other; having their latitudes, longitudes, seasons of the year, days and nights, all contrary to each other.

73. The *Right Ascension* of the sun, or a star, is that degree of the equinoctial, which rises with the sun or star, in a right sphere, and is reckoned from the point Aries eastward round the Globe.

74. The *Oblique Ascension* of the sun, or a star, is that degree of the equinoctial, which rises with the sun, or star, in an oblique sphere, and is reckoned from the point Aries eastward round the globe.

75. The *Oblique Descension* of the sun, or a star, is that degree of the equinoctial, which sets with the sun, or star, in an oblique sphere, and is also reckoned from the point Aries round the globe.

76. The *Ascensional* or *Descensional Difference*, is the difference between the right and oblique ascension, or between the right and oblique descension.

77. *Twilight* is that faint light which we perceive for some time before the sun rises, and after he sets. Twilight is said to begin in the morning, or it is daybreak, when the sun is within 18 degrees of the horizon; and it is said to end in the evening, when the sun is 18 degrees below the horizon.

78. The *Angle of Position* between two places on the globe, is an angle formed at the zenith of one of the places, by the meridian of that place, and a vertical circle passing through the other. It is measured on the horizon from the elevated pole towards the vertical circle.

79. *Rhumb Lines* are the lines drawn from the centre of the compass to the 32 points of the horizon. They are supposed to be drawn upon the earth, so as to cut each meridian at the same angle.

80. The *Achronycal Rising and Setting of the Stars.* When a star rises at sun setting, or sets with the sun, it is said to rise and set achronycally.

81. The *Cosmical Rising and Setting of the Stars.* When a star rises with the sun, or sets when the sun rises, it is said to rise and set cosmically.

82. *Heliacal Rising and Setting of the Stars.* When a star first becomes visible in the morning, after having been so near the sun as to be hid by the splendour of his rays, or when it first becomes invisible in the evening, on account of its nearness to the sun, it is said to rise and set heliacally.

83. A *Constellation* is a collection of stars on the celestial globe, circumscribed by the outlines of some assumed animal or figure, and serves to direct a person to any part of the heavens where a particular star is situated.

84. *Planets* are opaque bodies like our earth, moving round the sun, and shining by the reflection of his light. They are distinguished into primary and secondary.

85. The *Primary Planets* move round the sun as

their centre of motion. There are seven* primary planets, viz. Mercury, Venus, the Earth, Mars, Jupiter, Saturn, and Herschel.†

86. The *Secondary Planets, Satellites* or *Moons*, move round the primary planets a stheir centre of motion. There are 18 secondary planets; the Earth has one, Jupiter four, Saturn seven, and Herschel six.

87. The *Orbit of a Planet* is that imaginary path, which it describes round the sun.

88. *Nodes* are the two opposite points in the ecliptic, where the orbit of a planet appears to intersect it. That node from which the planet ascends northward from the ecliptic, is called the ascending node; and the other from which the planet descends southward, from the ecliptic, is called the descending node.

89. *Disc.* The apparently flat and circular faces of the sun and moon, are called their discs.

90. *Geocentric Latitudes and Longitudes of the Planets*, are their latitudes and longitudes as seen from the earth.

91. *Heliocentric Latitudes and Longitudes of the Planets*, are their latitudes and longitudes as seen from the sun.

92. *Eccentricity* of the orbit of any planet, is the distance between the centre of the planet's orbit and the sun.

93. *Transit* is the apparent passage of any planet over the sun's disc, or over the disc of another planet.

94. *Diurnal Arc of the Sun, Moon or a Star*, is that apparent arc which it describes in the heavens, from its rising to its setting.

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*Four new primary planets have been discovered since the year 1800; a brief description of which will be found under the head Solar System.

†Mercury and Venus are called inferior, or rather interior planets, because their orbits are within the orbit of the earth; and Mars, Jupiter, Saturn and Herschel are called superior or exterior planets, because their orbits are outside the orbit of the earth.

95. *Nocturnal Arc of the Sun, Moon, or a Star,* is the arc which it describes from its setting to its rising.

96. *The Parallax of any Celestial Body,* is the angle which the earth's semidiameter subtends as seen from that body.

97. *The Elongation of a Planet,* is the angle formed at the earth by two imaginary lines; the one supposed to be drawn to the sun, and the other to the planet.

98. *Conjunction.* Two celestial bodies are in conjunction when they are in the same point of the heavens.

99. *Opposition.* Two celestial bodies are in opposition when they are in opposite points of the heavens.

100. *Direct.* When a planet appears to move forward, or according to the order of the signs, its motion is said to be direct.

101. *Retrograde.* When a planet appears to move backward, or contrary to the order of the signs, its motion is said to be retrograde.

102. *Aphelion* is that point in the orbit of a planet which is farthest from the sun.

103. *Perihelion* is that point in the orbit of a planet which is nearest to the sun.

104. *Apogee* is that point in the orbit of a planet, the moon, &c. which is farthest from the earth.—

105. *Perigee* is that point in the orbit of a planet, the moon, &c. which is nearest to the earth.

THE SOLAR SYSTEM.

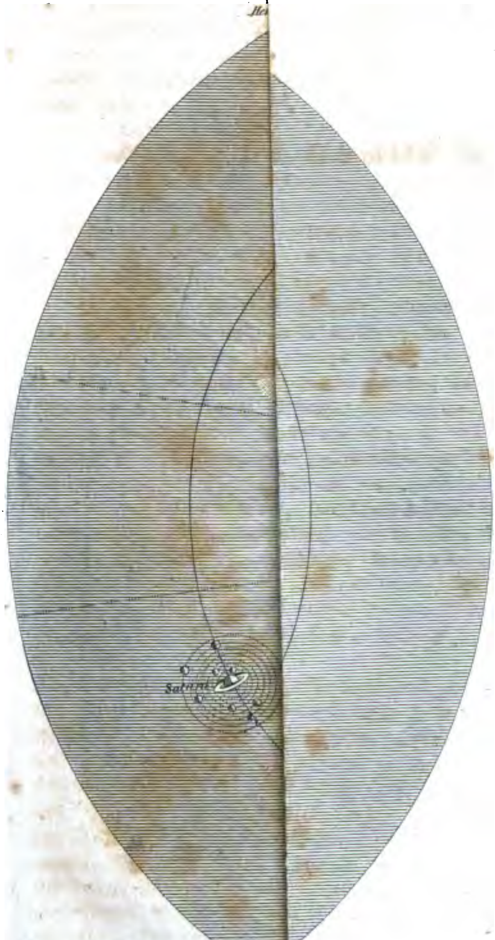
THE solar system (Plate 1) regards the sun as the centre of the universe, with all the planets revolving round him in elliptical orbits, at different distances, and in different periods of time. Those planets which are near the sun move faster in their orbits, and perform their circuits sooner than those more remote from him. This system is also called the Copernican System, on account of its famous founder, Nicolaus Copernicus; and it has latterly been demonstrated by Sir Isaac Newton in so satisfactory a manner, as to silence all the objections which can be made against it.

I. OF THE SUN—☉.

The SUN, the fountain of light and heat of the whole system, is situated near the common centre, or in one of the focuses, of the orbits of all the planets, and from the motion of spots on his surface, it is determined, that he revolves on his axis in 25 days, 14 hours, 8 minutes. These spots first appear on the eastern edge, and then gradually come forward towards the middle, and so pass on towards the western edge, and then disappear. The sun is agitated by a small motion round the centre of gravity of the solar system, which is produced by the various attractions of the circumvolving planets.

THE SOLAR SYSTEM

TE 1.



The sun's apparent diameter is longer in December than in June; hence he is nearer the earth in our winter than in summer, because the apparent magnitude of any distant body diminishes as the distance increases. The sun's mean distance from the earth is computed to be about 95 millions of miles;* and his mean apparent diameter is 32′ 1.5″; hence his real diameter will be 885,922 miles making his magnitude 1,376,554 times

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* Perhaps no problem appears more paradoxical and difficult than that of determining the distance of the sun from the earth to a degree of exactness; but from exact observations, even this can be effected.

That place in the heavens in which any celestial body would appear to a spectator at the earth's centre, is called its true place; and that place in which it appears at the same time to a spectator on the earth's surface, is called its apparent place. The difference between its true and apparent place is called its parallax. Thus, let C represent the earth's centre, (Plate 2, Fig. 1,) S the sun or any planet and A the place of a spectator on the earth's surface. At C, the sun would appear as at *c* in the heavens, his true place; and at A, at the same time he would appear as at *a* in the heavens, his apparent place. The angle *c* S *a* or C S A is equal to the difference between the sun's true and apparent place, equal to the sun's horizontal parallax, equal to the angle which the earth's semidiameter subtends as seen from the sun.

By the transit of Venus over the sun's disc (in the year 1761,) the sun's parallax, or the angle which the earth's semidiameter subtends as seen from the sun, was according to Mr. Short, 8″. 65 when the sun was at his mean distance from the earth. Hence the sun's distance from the earth is found as follows. In the right angled triangle A C S right angled at C, we have AC=the earth's semidiameter, and the angle A S C=the sun's horizontal parallax, to find A S the sun's mean distance from the earth. Therefore, it will be,

As sine ∠ ASC 8″.65- - - - -	5.6219140
Is to Radius 90° - - - - - - -	10.0000000
So is AC or 1 semidi. of the earth -	0.0000000
To S A or 23882.84 semidiam. - -	4.3780860

Then if 23882.84 be multiplied by 3982=the earth's semidiameter in miles, the product will be 95,101,468 miles, the distance of the sun from the earth.

that of the earth.* As the sun revolves on his axis, or on an imaginary line passing through his centre, his figure is supposed not to be exactly spherical, but a little flatted at the poles, as our earth. The axis of the sun makes an angle of 8 degrees with the axis of the earth's orbit.

II. OF MERCURY—☿

Mercury, the nearest of all the planets, to the sun, performs his periodical revolution round him in 87 days, 23 hours, 15 minutes, 43 seconds of our time; which is the length of his year. The inclination of his axis to the plane of his orbit, and the time of his rotation on his axis, being unknown, it follows, that the vicissitudes of his seasons, and the length of his days and nights, are likewise unknown. Mercury appears to us, when viewed at different times through a telescope, with all the phases of the moon, except that he ne-

*Let E represent the earth (Plate 2, Fig. 2,) S the sun, draw the diameter A B, and join E A and E B; now in the triangle E A B, are given the angle A E B=32′ 1.5″=the sun's apparent diameter, and each of the angles E A B, E B A $=\dfrac{180^\circ-32'\ 1.5''}{2}=$ 89° 43′ 59″, and the side E A or E B.=23882.84 semidiameters of the earth, to find A B. Hence,

As sine ∠ E A B 89° 43′ 59″	- - -	9.9999953
Is to sine ∠ A E B 32′ 1.5″	- - -	7.9692039
So is E B or 23882.84 semidiam.	- -	4.3780860
		12.3472899
		9.9999953
To A B or 222.4818 semidiameters	-	2.3472946

Therefore 222.4818 × 3982=885922.5276 miles, the diameter of the sun; and as the magnitudes of spherical bodies are as the cubes of their diameters (Euclid XII. and 18th,) it follows that the cube of 885922.5276 being divided by the cube of 7964 gives 1,376,554, which shows how many times the sun is greater than the earth.

ver appears quite full; because his enlightened side is never directly opposite to us, but when he is so near the sun as to be lost to our sight in the beams of that luminary. His enlightened side being always towards the sun, and his never appearing full, evidently prove, that he shines not by any light of his own; for if he did, he would always appear circular like the sun; and his never appearing above the horizon at midnight, evidently show, that his orbit is contained within the orbit of the earth, otherwise he would be seen in opposition to the sun.

The orbit of Mercury is inclined 7 degrees to the ecliptic, and that node from which he ascends northward above the ecliptic, is in the 15th degree of Taurus; and consequently, the descending node is in the 15th degree of Scorpio. The earth is in these points on the 5th of May and 6th of November, and when Mercury comes to either of his nodes at his inferior conjunction (that is when he is in the nearer part of his orbit between the earth and the sun) about these times, he will pass over the disc of the sun, like a dark round spot;* but in all other parts of his orbit, he will go eith-

* Let S be the sun (Plate 2, Fig. 3,) P an interior planet, as Mercury or Venus, E the earth, and ABC a portion of the heavens. When the planet P is at its inferior conjunction, at *a* it will be invisible, because its dark side is turned towards E the earth; unless it be in one of its nodes, in which case it will be seen to pass over the sun's disc like a dark spot. As the planet P advances in its orbit from *a* to *b*, its enlightened side will become gradually visible, it will appear west of the sun, and will then be a morning star. When it has arrived at *b*, or at its greatest western elongation, half its enlightened side will be seen from E the earth like a half moon. Now during this motion of the planet from *a* to *b*, it will appear to a spectator at E to move from B to A in the heavens, or to go backwards, which is called its retrograde motion; and during its motion, from *b* to *c* it will appear to move from A to B in the heavens or forward, called its direct motion; and when at *c*, it will appear in the same place in the heavens as when at *a*, being then in its superior conjunction. In going from *c* to *d*, it will become east of the sun and an evening star, and will appear to move

er above or below the sun, and consequently his conjunctions are then invisible.

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from B to C in the heavens; and when moving from *d*, or its greatest eastern elongation, to *a*, it will appear to go backwards again in the heavens from C to B, and when at *a* it again disappears and passes by the sun.

From this we have an easy method of finding the distance of the interior planets Mercury and Venus from the sun, for, by joining *b* S, we have in the right angled triangle EbS, right angled at *b*, the angle S E b,=the planets greatest elongation, and E S=the distance of the sun from the earth, to find, *b*S the planet's mean distance from the sun. Mercury's greatest elongation is 28° 20′ when he is in his aphelion and the earth in its perigee, but when Mercury is in his perihelion and the earth in its apogee, the greatest elongation is 17° 36′; the mean is therefore 22° 58′. Then

As Radius 90° - - - - - - -	10.0000000
Is to sine ∠ S E b 22° 58′ - -	9.5912823
So is E S or 23882.84 semidiam. - -	4.3780860
To b S or 9318.978 semidiam. -	3.9693683

Therefore 9318.978 × 3982 gives 37,108,170 miles, the distance of Mercury from the sun.

The distance of any planet from the sun may be found by Kepler's rule. Thus, the squares of the times in which the planets revolve round the sun are as the cubes of their mean distances from him; or, the square of the time in which the earth revolves round the sun, is to the square of the time in which any other planet revolves round the sun, as the cube of the mean distance of the earth from the sun, is to the cube of the planets mean distance from the sun. Or, shorter, thus divide the square of the time in which any planet revolves round the sun, by the square of the time in which the earth revolves round him, and the cube root of the quotient will give the planet's relative distance from the sun, which being multiplied by the earth's mean distance from the sun, will give the planet's mean distance required.

The earth's siderial revolution round the sun is 365 d. 6 h. 9 m. 12 sec = 31558152 seconds; the square of which is 995916957655104. Mercury revolves round the sun in 87 d. 23 h. 15 m. 43 sec = 7600543 seconds; the square of which is 57768253894849; this divided by the former gives .058005091138, the cube root of which is .387099 nearly, the distance of Mercury from the sun, supposing the distance of the earth from the sun to be 1.

Mercury's apparent diameter is stated to be 11″, and his distance from the sun 37 millions of miles; hence his real diameter is about 3107 miles;* and his magnitude about one-seventeenth that of the earth. The light and heat which this planet receives from the sun are about seven times as great as that which the earth receives.† Mercury is but seldom seen; he appears a little after sunset, and again a little before sunrise. He emits a brilliant white light, and twinkles like the fixed stars.

III. OF VENUS—♀.

VENUS, the next planet in order, performs her revolution round the sun in 224 days, 16 hours, 49 minutes, 10 seconds; her orbit, including that of Mercury

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Hence, .387099 × 23882.84 = 9245.02348, the distance of Mercury from the sun in semidiameters of the earth; and, 9245.02348 × 3982 = 36813683 miles, the mean distance of Mercury from the sun, according to this method.

* Mercury's real diameter may be found thus—the mean distance of the earth from the sun is 23882.84 semidiameters, and the mean distance of Mercury from the sun is 9245.02348 semidiameters; the difference is 14637.81652 semidiameters; the distance of Mercury from the earth at his inferior conjunction; and as the apparent magnitudes of bodies are inversely as their distances, it will be as 23882.84 : 14637.81652 : : 11″ : 6.74″, the apparent diameter of Mercury at a distance from the earth equal to that of the sun. And because the sun's apparent diameter is 32′ 1.5″, and his real diameter 885922.5276 miles, it will be as 32′ 1.5″ : 6.74″ : : 885922.5276 m. : 3107.5 miles, the real diameter of Mercury. Then if the cube of the earth's diameter be divided by the cube of Mercury's diameter, the quotient will be 16.8, which shows how many times the magnitude of the earth exceeds that of Mercury.

† The effects of light and heat decrease as the squares of the distances of the planets from the sun increase; therefore, if the square of the distance of the earth from the sun, be divided by the square of Mercury's distance from the sun, the quotient will show how many times the light and heat which Mercury receives from the sun, are greater than that which the earth receives from him.

within it, is within the earth's orbit; for if it were not she might be seen as often in opposition to the sun, as she is in conjunction with him; but she was never seen above the horizon at midnight, or 90 degrees from the sun. Venus, when viewed through a telescope, has all the phases of the moon, though she never or seldom appears perfectly round.

When Venus appears west of the sun, or when her longitude is less than the sun's longitude, she will rise in the morning before him, and is then called a morning star; but when she appears east of the sun, or when her longitude is greater than the sun's longitude, she shines in the evening after sunset, and is then called an evening star. Venus is a morning star for about 290 days, and an evening star for the same length of time, though she performs her entire revolution round the sun in 224 days, 16 hours, 49 minutes, 10 seconds, as above stated. It may be very naturally asked, why Venus appears longer to the east or west of the sun, than the whole time of her revolution round him? But this is easily answered, when we consider that while Venus is going round the sun, the earth is going round him the same way, though not so quick; and therefore the relative motion of Venus to the earth, is slower than her absolute motion in her orbit.

The orbit of Venus makes an angle of 3° 23′ 35″ with the ecliptic, and her ascending node is 14 degrees in Gemini, hence the descending node is 14 degrees in Sagittarius, and therefore, when the earth is in or near these points of the ecliptic, at the time that Venus is in her inferior conjunction, she will appear like a dark spot on the sun's disc. The last transit of Venus, was in the year 1769. The apparent diameter of Venus is stated to be 58″ and her distance from the sun 68 millions of miles;* hence her real diameter is about 7386

* The distance of Venus from the Sun, may be found by her greatest elongation, exactly in the same manner, as that of Mer-

miles*, and her magnitude something less than that of the earth. The light and heat which this planet receives from the sun, are about double the light and heat which the earth receives from him. The inclination of the axis of Venus to her orbit, and the time she takes to revolve on her axis, have been given by several astronomers, differing from each other. Venus, to appearance, is the largest of all the planets, and is distinguished from them by the brilliancy and whiteness of her light.

IV. OF THE EARTH—⊕

And its Satellite the Moon—☽

1. The Earth, the next planet above Venus, is a globe of about 7964 miles in diameter,† revolving once on its axis, from west to east, in 23 hours, 56 minutes, 4 seconds, which is the time elapsed from the passage of any fixed star over the meridian till it returns to the same meridian again. This motion of the earth causes all the heavenly bodies to have an apparent diurnal motion

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cury, in the notes page 30, only using 46° 22′, the greatest elongation of Venus, instead of Mercury's greatest elongation. Thus;

As Radius 90° - - - - - - -	10.0000000
Is to sine 46° 22′ - - - - - - -	9.8596009
So is 23882.84 semidiameters - - -	4.3780860
To 17285.69 semidiameters - - - -	4.2376869

Therefore, 17285.69×3982=68831617 miles, the distance of Venus from the sun. The distance of Venus from the sun, may also be found by Kepler's rule. See the note page 30.

*For 23882.84—17285.69=6597.15 semidiameters, the distance of Venus from the earth; and, as 23882.84 : 6597.15 : : 58″ : 16″.02; and again, as 32′ 1.5″ : 16″.02 : : 885922.5276 m. : 7386 miles the diameter of Venus. See the note page 31.

†Mr. Richard Norwood measured the length of a degree between London and York, and found it equal to 367196 feet, or 69½ English miles nearly, which being multiplied by 360, gives 25020 miles, the circumference of the earth; and 25020 divided by 3.1416 gives 7964 miles its diameter.

in the same time from east to west, making the vicissitudes of day and night.

The earth is about 95 millions of miles from the sun, and performs its annual motion round him, describing an elliptical orbit, in 365 days, 5 hours, 48 minutes, 49 seconds, from any equinox or solstice to the same again, travelling at the rate of upwards of 68,000 miles per hour.* Besides this rapid motion which is common to every place on the earth, the inhabitants of the equator are carried 1042 miles per hour by the diurnal revolution of the earth on its axis.† The earth's axis makes an angle of 23° 28′ with the axis of its orbit, and preserves the same oblique direction during its annual course, or keeps always parallel to itself; hence during one part of the earth's course, the north pole is turned towards the sun, and during another part of its course, the south pole is turned towards him in like manner; which causes the different seasons of the year.

That the earth is spherical or nearly so, is not only evident from its shadow upon the moon in lunar eclipses, which shadow is always bounded by a circular line, but also from the many ciscumnavigators who sailed round it at different times from west to east, and the many observations made by persons at sea or on the shore, in viewing a vessel depart from them; they first lose sight of the hull, while they can see the rigging and topsails; but as she recedes farther from them, they gradually lose sight of these also, the whole being hid by the convexity of the water.

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* The diameter of the earth's orbit is 190 millions of miles, or twice the distance of the earth from the sun; and 190,000,000 $\times$ 3.1416 = 596,904,000 miles, the circumference of the orbit; and because the earth describes this circumference in 365 d. 6 h. or 8766 hours, it will be, as 8766 h. : 1 h. : : 596,904,000 m. : 68093 miles, the earth's hourly motion in its orbit.

† The circumference of the earth is 25020 miles, and it revolves once on its axis in 24 hours, therefore 25020 miles divided by 24, gives 1042 miles per hour, the inhabitants of the equator are carried by the diurnal rotation of the earth on its axis.

Though the earth may be considered as spherical, yet it has been discovered, that it is not truly so. This matter was the occasion of great disputes between the philosophers of the last age, among whom Sir Isaac Newton and Cassini, a French astronomer, took the most active part in the controversy. Sir Isaac demonstrated from mechanical principles, that the earth was an *oblate spheroid*,* or that it was flatted at the poles; the polar diameter being shorter than the equitorial diameter. The French astronomer asserted the contrary, or that the earth was a *prolate* *spheroid;* the polar diameter being longer than the equitorial diameter.—The French King, in 1736, being desirous to end the dispute, sent out two companies of the ablest mathematicians then in France, the one towards the equator, and the other towards the north pole, in order to measure a degree of a meridian in these different parts. From the results of these admeasurements, the assertions of Cassini were rejected, and those of Newton confirmed beyond dispute. Therefore, since that time, the earth has been considered as an *oblate spheroid*, having the diameter at the equator to the polar diameter, as 230 to 229. But this difference is so small, and the unevenness of the earth's surface arising from the mountains, hills, &c. so inconsiderable, when compared with its magnitude, that in all practical sciences, we may consider the earth as a sphere; and hence, the artificial globes, being made perfectly spherical, are the best representations of the earth.

2. The Moon is the nearest celestial body to the earth, and the next to the sun, from appearance, in splendor; her mean distance from the earth is 236,849

* A *spheroid* is a solid generated by the revolution of a semi-ellipsis about one of its diameters which remains fixed. If the *conjugate* diameter remain fixed, the *spheroid*. is *oblate*; but if the *transverse* diameter be fixed it is *prolate*.

miles,* and she performs her revolution round the earth in 27 days, 7 hours, 43 minutes, 5 seconds, which is the length of the periodical month, travelling at the rate of 2,270 miles† per hour round the earth, besides her motion in attending the earth round the sun every year.

The moon's orbit is inclined to the ecliptic in an angle of about 5° 10′ at a medium, and her axis is nearly perpendicular to the ecliptic, consequently she has little or no diversity of seasons. The time which the moon takes to revolve on her axis, is equal to the time which she takes to go round the earth from new moon to new moon again, being 29 days, 12 hours, 44 mintes, 3 seconds, which is the length of the synodical month; therefore, she has always the same side turned towards the earth. The moon's apparent diameter is 31′ 8″, hence her real diameter is 2,144 miles, and her magnitude about one-fiftieth of the magnitude of the earth.†

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† Let A C (plate 2, Fig. 4.) represent the semidiameter of the earth, M the moon, and join A M and C M. Then in the right angled triangle A C M right angled at C, we have the angle A M C, or a M c, = the difference between the true and apparent place of the moon = the moon's horizontal parallax, and A C = the semidiameter of the earth, to find A M = the moon's mean distance from the earth. The moon's horizontal parallax at a medium, is 57′ 48″. Therefore:

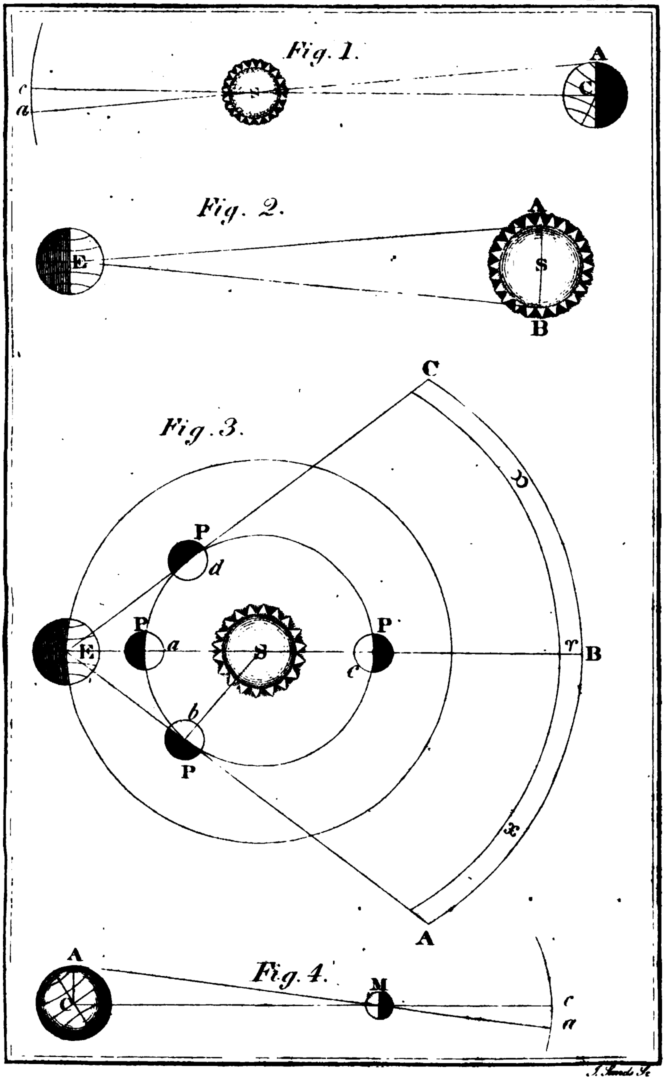
As sine ∠ A M C	57′ 48″ - -	8.2256230
Is to Radius	90° - - -	10.0000000
So is A C or 1 semidiam.	- - -	0.0000000
To A M or 59.48 semidiam.	- - -	1.7743770

Then 59.48 × 3982 = 236849 miles, the mean distance of the moon from the earth.

*For 236849 × 2 = 473698 miles, the diameter of the moon's orbit, and 473698 × 3.1416 = 1488169 miles, the circumference of her orbit; therefore. as 27d. 7h. 43m. 5 sec. : 1h. : : 1488169m. : 2269.5 miles the moon's hourly motion in her orbit.

† The moon's horizontal parallax is 57′ 48″, which is equal to the angle which the earth's semidiameter subtends as seen from the moon; and 57′ 48″ × 2 = 1° 55′ 36″, the apparent di-

Pl. 2.



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The moon is an opaque body like our earth, and shines by reflecting the light which she receives from the sun, hence she disappears when she comes between us and the sun, being then new moon or at the change. When she has advanced a little in her orbit eastward, we see a little of her enlightened side, the convex part being towards the sun, and the horns towards the east; and as she advances forward, her enlightened side increases to our view, until she comes to be opposite to the sun, and consequently her whole enlightened side is then turned towards the earth, appearing like a complete luminous circle, which we then call full moon. When the moon has advanced a little further eastward in her orbit, a part of her dark side is then turned towards the earth, and she is become deficient on the western edge, the convex part being towards the east, and the horns towards the west; and as she advances still farther eastward, her dark side turns gradually towards the earth, until she comes again between the earth and the sun, having the whole of her dark side towards the earth, it being new moon again or at the change. The earth is a moon, to the moon, but appears 13 times as large to the moon, as the moon appears to us.* When the moon is full to us, the earth is new moon to her, and when she is in her first quarter to us, the earth is in her third quarter to her; and the contrary.

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ameter of the earth as seen from the moon. Therefore, as 1° 55′ 36″ : 31′ 8″ : : 7964m. : 2144 miles, the diameter of the moon. Or the moon's diameter may be found by Trigonometry in the same manner as that of the sun (see note page 28.) And if the cube of the earth's diameter be divided by the cube of the moon's diameter, the quotient will show how many times the magnitude of the earth exceeds that of the moon.

* This is found by dividing the square of the earth's diameter by the square of the moon's diameter. Euclid XII and 2d.

V. OF MARS—♂.

Mars, the first planet without the earth's orbit, is computed to be about 144* millions of miles from the sun, and goes round him in 686 days, 23 hours, 30 minutes, 35 seconds, travelling at the rate of upwards of 55,000 miles per hour. The axis of Mars is perpendicular to the ecliptic, and he revolves once on it in 24 hours, 39 minutes, 22 seconds. The orbit of Mars is inclined 1° 51′ to the ecliptic, and his ascending node is 18 degrees in Taurus. Mars is sometimes in conjunction with the sun, but he was never seen to pass over the sun's disc. He appears sometimes round and full, and at other times gibbous, but never horned; therefore, from these appearances it is manifest, that he shines not by his own light, and that his orbit is more distant from the sun, than the earth's orbit. Mars sometimes rises before the sun in the morning, and is then a morning star; at other times he shines in the evening after sunset, and is then an evening star. He appears of a dusky red colour, from which it is supposed that he is surrounded by a very gross atmosphere. The diameter of Mars is stated to be 4,189 miles, hence his magnitude is but a little more than one-seventh of that of the earth.†

VI. OF THE FOUR NEW PLANETS, CERES, PALLAS, JUNO, AND VESTA.

1. The planet Ceres was discovered at Palermo, in Sicily, by M. Piazzi, on the 1st of January, 1801. This

*The distance of Mars from the sun may be found from his periodic time by Kepler's rule. (See the note page 30.)

†For if the cube of 7964 be divided by the cube of 4189 the quotient will be 6.87, which shows that the earth is nearly seven times as large as Mars.

new celestial body is situated between the orbits of Mars and Jupiter, and performs her revolution round the sun in 4 years, 7 months, and 10 days, at the mean distance of 260 millions of miles from him. Very little is known at present, to any degree of certainty, respecting this planet. The diameter of Ceres has been differently stated by different astronomers; according to Dr. Herschel, it does not exceed 160 miles. Ceres is invisible to the naked eye.

2. The planet PALLAS was discovered at Bremen, by Dr. Olbers, on the 28th of March, 1802. It is situated between the orbits of Mars and Jupiter. The distance of this planet from the sun, periodical revolution and magnitude, have not yet been determined with sufficient accuracy.

3. The planet JUNO was discovered at Lilienthal, near Bremen, by Mr. Harding, on the 1st of September, 1804. It is situated between the orbits of Mars and Jupiter. Its mean distance from the sun, and its magnitude, are less than those of the other new planets.

4. The planet VESTA was discovered by Dr. Olbers, on the 29th of March, 1807. It is situated about the same distance from the sun as the other three. Vesta is of the fifth or sixth magnitude, and may be seen by the naked eye.

VII. OF JUPITER—♃

And his Satellites.

1. JUPITER, the largest of all the planets, is computed to be about 490* millions of miles from the sun, and

*The distance of Jupiter from the sun may be found (as in the note page 30,) in the same manner as that of Mercury or any other planet.

goes round him in 4332 days, 14 hours, 27 minutes, 10 seconds, moving at the rate of upwards of 29,000 miles per hour in his orbit. The inclination of the orbit of Jupiter to the plane of the ecliptic is 1° 18′ 56″, and his ascending node about 8 degrees in Cancer. The apparent diameter of Jupiter is stated to be 39″ and his real diameter 89,170 miles; hence his magnitude is about 1400* times that of the earth. Jupiter revolves once on his axis in 9 hours, 56 minutes, which is nearly perpendicular to the plane of his orbit, and consequently, he has no diversity of seasons. When Jupiter is opposite to the sun, that is, when he comes to the meridian at midnight, he is then nearer to the earth than he is for sometime before or after his conjunction; and consequently, at the time of opposition, he appears larger and shines with greater lustre than at other times. Jupiter is a morning star, when his longitude is less than the sun's longitude, or when he appears to the west of the sun; and he is an evening star, when his longitude is greater than the sun's longitude, or when he appears to the east of the sun. Sometimes Jupiter appears nearly as large as Venus, though his nearest distance from the earth is fifteen times the nearest distance of Venus from it.

Jupiter is surrounded by faint substances, called belts, which from their many changes in situation and appearance are generally supposed to be clouds. Large dark spots have been observed between these belts, and when any belt disappears, the contiguous spots are known to disappear also.

On account of the quick velocity with which this huge planet revolves on his axis, he is much more flatted at the poles than the earth. The equitorial diameter is stated to be to the polar diameter as 13 to 12.—

*Found by dividing the cube of Jupiter's diameter by the cube of the earth's diameter.

The light and heat which Jupiter receievs from the sun, are about one twenty-seventh* of the light and heat which the earth receives; but the quick returns thereof, and the four satellites which attend him, compensate for the deficiency.

2. Jupiter has four satellites, or moons, which revolve round him as follows: the first satellite, or that nearest to Jupiter, performs its revolution round him in 1 day, 18 hours, 27 minutes, 33 seconds, and is 252,000 miles distant from his centre; the second revolves round him in 3 days, 13 hours, 13 minutes, 42 seconds, at 400,000 miles distance; the third in 7 days, 3 hours, 42 minutes, 33 seconds, at 640,000 miles distance; and the fourth in 16 days, 16 hours, 32 minutes, 8 seconds, at the distance of 1,126,000 miles from his centre.

Galileo, the inventer of telescopes, discovered Jupiter's satellites, which are invisible to the naked eye, in the year 1610. This was a very important discovery; for as these satellites are frequently eclipsed by Jupiter's shadow, astronomers have not only discovered the progressive motion of light, but have also found the longitudes of places on land with a greater degree of exactness than by any other method yet known. The first satellite, or that nearest to Jupiter, is the most important of the four, because its motion round Jupiter is quicker than that of any of the others; and therefore its eclipses are more frequent.

The times of the eclipses of Jupiter's satellites are given in the Nautical Almanac for every month, and calculated for the meridian of Greenwich. Now, let an observer with a good telescope observe the beginning or end of one of these eclipses at any place, and note the precise time that he saw the satellite immerge

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*Found by dividing the square of the distance of Jupiter from the sun, by the square of the distance of the earth from the sun.

into or emerge out of the shadow of Jupiter; the difference between this time, and that given in the Almanac, will be the difference of time between Greenwich and the place of observation; hence, the true longitude of the latter from the former is easily obtained.

VIII. OF SATURN—♄,

His Satellites and Ring.

1. SATURN, the farthest from the sun of any of the planets that are visible to the naked eye, is computed to be 900 millons* of miles from him, and goes round him in 10,759 days, 1 hour, 51 minutes, 11 seconds, travelling at the rate of about 22,000 miles per hour in his orbit. The inclination of the orbit of Saturn to the plane of the ecliptic is 2° 29′ 51″, and his ascending node about 21° in Cancer. Saturn's diameter is about 79,042 miles; and his magnitude 977 times that of the earth. Saturn revolves on his axis in 10 hours, 16 minutes, 2 seconds, but in the inclination of his axis orbit is uncertain.

The light and heat which this planet receives from the sun, are about one-ninetieth of the light and heat which the earth receives. Saturn emits a pale faint light.

2. Saturn is attended by no less than seven satellites, or moons, which supply him with light during the sun's absence. The times of the revolutions of these satellites round Saturn, and their respective distances from him, are as follows:

*The distance of Saturn from the sun may be found in the same manner as that of any other planet.

6, revolves in	0*d*.	22*h*.	37*m*.	23*s*.	dist. fr. S.	111,000
7,	1	8	53	9		140,000
1,	1	21	18	26		172,000
2,	2	17	44	51		216,000
3,	4	12	25	11		315,000
4,	15	22	41	13		708,000
5,	79	7	53	43		2,126,000

The sixth and seventh satellites were discovered by Dr. Herschel in the year 1789; they are nearer to Saturn than any of the rest, and should be called the first and second; but they are here named in the order of their discovery.

3. Saturn is encompassed by a broad opaque circular ring without touching him, like the wooden horizon of an artificial globe. This ring was first discovered by Huygens; and afterwards, Dr. Herschel, by the assistance of his powerful telescopes. discovered it to be double, or to consist of two concentric rings, detached from each other. The breadth of the innermost ring is nearly three times that of the outermost. There have been various conjectures relative to the nature of this ring. It casts a shadow upon Saturn, and appears more luminous than that planet himself; hence, the general conclusion is, that it is a solid body, equal in density to Saturn.

IX. OF HERSCHEL—♅,

And his Satellites.

1. Herschel was discovered on the 13th of March 1781, by Dr. Herschel. This planet is situated beyond the orbit of Saturn, at the distance of 1,800,000,000 miles from the sun, and performs his revolution round him in 30,737 days, 18 hours. The apparent diameter of Herschel, is stated to be 3.54″ and real di

ameter, 35,112 miles; hence, its magnitude is about 85 times that of the earth. The inclination of its axis to the orbit, and the time of its diurnal rotation, are not yet determined. Herchel can scarcely be distinguished by the naked eye, even in a clear night, and in the moon's absence.

2. Herschel is attended by six satellities, all of which were discovered by Dr. Herschel. The times of their revolutions round it, and when discovered, are as follow:

1, revolves	in 5*d.*	21*h.*	25*m.*	0*s.*	discovered in	1798.
2,	8	17	1	19		1787.
3,	10	23	4	0		1798.
4,	13	11	5	1		1787.
5,	38	1	49	0		1798.
6,	107	16	40	0		1798.

These satellites are said to move in orbits lying in the same plane, and nearly perpendicular to the ecliptic. They move in a retrogade direction, (a remarkable circumstance,) or contrary to the order of the signs.

TABULAR VIEW OF THE SOLAR SYSTEM.

Names of the Planets.	Mean distance from the Sun in miles.	Sidereal Revolutions.	Apparent diameters	Real diameter in miles.	Proportional magnitudes, the Earth being one.
The Sun			32′ 1.5″	885,922	1,376,554
Mercury	37,000,000	87d. 23h. 15′ 43″	11	3107	0.0594
Venus	68,000,000	224 16 49 10	58	7386	0.7976
The Earth	95,000,000	365 6 9 12	- -	7964	1.
The Moon	95,000,000	- - - -	31 8	2144	0.0197
Mars	144,000,000	686 23 30 35	27	4189	0.1455
Vesta	225,000,000	- - - -	- -	238	-
Juno	252,000,000	- - - -	- -	1425	-
Ceres	263.000,000	- - - -	- -	163	-
Pallas	265,000,000	- - - -	- -	80	-
Jupiter	490,000,000	4332 14 27 10	39	89170	1400
Saturn	900,000,000	10759 1 51 11	18	79042	977
Herschel	1,800,000,000	30737 18 0 0	3.54	35112	85.18

Plate 3. Fig. 1. Represents the magnitudes of the seven primary Planets proportional to each other, and to a supposed globe of about 15 inches in diameter for the Sun. In proportion to the distances of the planets from the Sun, the distance of Mercury from a sun of 15 inches in diameter, would be 17 yards; Venus 32 yards, the earth 44 yards; Mars 67 yards; Jupiter 228 yards; Saturn 418 yards; and Herschel 836 yards. According to this the proportional distance of the Moon from the earth would be only about 4 inches.

X. OF COMETS.

Comets are solid opaque bodies, which occasionally visit the solar system. They are supposed to move round the sun in elliptical orbits, having him in one of the focuses. These orbits are so very eccentric, that when the comet is in that part of its orbit which is farthest from the sun, it becomes invisible, and after traversing the remote portion of its orbit, unseen for years, it makes its appearance again. Comets have tails turned from the sun, which are supposed to be vapours produced by the excessive heat of that luminary. It would be useless to give the wild and extravagant opinions which have been entertained by some astronomers respecting these celestial bodies.

THE FIXED STARS.

The fixed stars are so called, because they are known to keep nearly in the same position, and at the same distances from each other. They have an apparent motion from east to west, which is caused by the diurnal motion of the earth from west to east. The precession of the equinoxes will cause the fixed stars to vary in their situations, and hence their latitudes and longitudes, in the course of half a century, will vary considerably; therefore, it becomes necessary to have new plates engraven for the celestial globes once in about every fifty years.

When the fixed stars are viewed through a good telescope, they appear less than when viewed by the naked eye The number of fixed stars which are visible to the naked eye in both hemispheres, does not exceed 3000, though at first view, they may appear infinite in number. The stars, on account of their apparently various magnitudes, are divided into classes. Those which appear the largest, are called stars of the first magnitude; the next to these in appearance, stars of the second magnitude; and so on to the sixth magnitude, which are the smallest that can be seen by the naked eye.

That bright luminous zone in the heavens, which is called the Milky-way, is composed of a vast number of small stars, which by their joint light, cause that whiteness so perceptible in a clear night.

Astronomers have computed that the nearest of the fixed stars from the earth, is not less than 20,000,000, 000,000 miles. At a distance so immensely great, it is impossible for them to shine by the reflected light of the sun; and therefore it is inferred, that they are of the same nature with the sun, and shine by their own light.

The heavens are divided into three principal parts. 1, the Zodiac; 2, all that part of the heavens on the north side of the Zodiac; and 3, all that part on the south side of it. These are again subdivided into constellations, in order to direct a person to any part of the heavens where a particular star is situated. The constellations in the Zodiac are twelve in number, the northern constellations 34, and the southern 47, making in all 93.

The stars in each constellation are denoted by the letters of the Greek and Roman alphabets; by placing the first Greek letter α to the principal star, β to the second in magnitude, γ to the third, and so on till the Greek alphabet is finished; then beginning with the Roman letters, *a*, *b*, *c*, &c. This useful method of denoting the stars, was first introduced by John Bayer, of Augsburg in Swabia, about the year 1603. When any constellation contains more stars than can be marked by the two alphabets, the numbers, 1, 2, 3, are used in succession.

The following Tables contain all the constellations on the *New British Globes*, and the names of many of the principal stars.

I. CONSTELLATIONS IN THE ZODIAC.

NAMES OF THE CONSTELLATIONS.	Principal Stars in their Magnitudes.	Number of Stars.
1. Aries, *the Ram,*	Arietes, 2.	67
2. Taurus, *the Bull,*	Aldebaran, 1.	143
3. Gemini, *the Twins,*	Castor, 1.	87
4. Cancer, *the Crab,*		87
5. Leo, *the Lion,*	Regulus, 1.	101
6. Virgo, *the Virgin,*	Spica Virginis, 1.	117
7. Libra, *the Balance,*		55
8. Scorpio, *the Scorpion,*	Antare 1.	37
9. Sagittarius, *the Archer,*		73
10. Capricornus, *the Goat,*		54
11. Aquarius, *the Water-bearer,*	Scheat, 3.	119
12. Pisces, *the Fishes,*		115

II. THE NORTHERN CONSTELLATIONS.

NAMES OF THE CONSTELLATIONS.	Principal Stars and their Magnitudes.	Number of Stars.
1. Ursa Minor, *the Little Bear,*	Pole Star, 2.	26
2. Ursa Major, *the Great Bear,*	Dubhe, 2.	105
3. Cor Caroli, *Charle's Heart,*		3
4. Draco, *the Dragon,*	Rastaben, 2.	87
5. Cepheus, *Cepheus,*	Alderamin, 3.	58
6. Cassiopeia, *the Lady in her chair,*	Schedar, 3.	64
7. Cameleopardalus, *the Cameleopard,*		78
8. Cygnus, *the Swan,*	Denib, 1.	83
9. Lynx, *the Lynx,*		48
10 Lacerta, *the Lizard,*		18
11 Auriga, *the Waggoner,*	Capella, 1.	71
12 Perseus, *Perseus,*	Algol, 2.	73
13 Musca, *the Fly,*		13

NAMES OF THE CONSTELLATIONS.	Principal Stars and their Magnitudes.	Number of Stars.
14. Triangula, *the Triangles,*		17
15. Andromeda, *Andromeda,*	Mirach, 2.	73
16. Lyra, *the Harp,*	Lyra, 1.	25
17. Hercules, *Hercules,*	Ras Algethi, 3.	119
18. Corona Borealis, *the Northern Crown,*	Gemma, 2.	21
19 Bootes, *Bootes,*	Arcturus. 1.	64
20. Canes Venatici, *the Greyhounds,*		36
21. Coma Berenices, *Berenices Hair,*		48
22. Leo Minor, *the Little Lion,*		59
23. Mons Mænalus, *the Mountain Mœnalus,*		11
24. Serpens, *the Serpent,*		65
25. Serpentarius, *the Serpent-bearer,*	Ras Alhagus, 2.	79
26. Taurus Poniatowski, *the Bull of Poniatowski,*		7
27. Scutum Sobieski, *the Shield of Sobieski,*		7
28. Aquilla, *the Eagle,* 29. Antinous, *Antinous,*	Altairi 1.	71
30. Delphinus, *the Dolphin,*		19
31. Sagitta, *the Arrow,*		18
32. Vulpecula et Anser, *the Fox and Goose,*		36
33. Equulus, *the Horse's Head,*		10
34, Pegasus, *the Flying Horse*	Markab, 2.	89

III. THE SOUTHERN CONSTELLATIONS.

NAMES OF THE CONSTELLATIONS.	Principal Stars and their Magnitudes.	Number of Stars.
1. Cetus, *the Whale,*	Menkar, 2.	99
2. Eridanus, *the River Po,*	Archerner, 1.	70
3. Brandenburgium Sceptrum, *the Sceptre of Brandenburgh,*		3
4. Lepus, *the Hare,*		20
5. Orion, *Orion,*	Rigil, 1.	82
6. Canis Major, *the Great Dog,*	Sirius, 1.	31
7. Monoceros, *the Unicorn,*		31
8. Canis Minor, *the Little Dog,*	Procyon, 1.	18
9. Hydra, *the Hydra,*	Cor Hydra, 1.	62
10. Sextans, *the Sextant,*		44
11. Crater, *the Goblet,*	Alkes, 3.	31
12. Corvus, *the Crow,*	Algorab, 3.	10
13. Pyxis Nautica, *the Mariner's Compass,*		14
14. Machina Pneumatica, *the Air Pump,*		20
15. Crux, *the Cross,*		12
16. Centaurus, *the Centaur,*		35
17. Lupus, *the Wolf,*		24
18. Norma, *the Rule,*		15
19. Circinus, *the Compasses,*		10
20. Triangulum Australe, *the South Triangle,*		13
21. Ara, *the Altar,*		9
22. Telescopium, *the Telescope,*		21
23. Corona Australis, *the Southern Crown,*		12
24. Pavo, *the Peacock,*		36
25. Indus, *the Indian,*		34
26. Microsopium, *the Microscope,*		13

NAMES OF THE CONSTELLATIONS.	Principal Stars and their Magnitudes.	Number of Stars.
27. Piscis Australis, *the Southern Fish,*	Fomalhaut, 1.	24
28. Grus, *the Crane,*		44
29. Toucan, *the American Goose,*		33
30. Phœnix, *the Phœnix,*		48
31. Apparatus Sculptoris, *the Sculptor's Apparatus,*		32
32. Fornax Chymiæ, *the Chymist's Furnace,*		43
33. Horologium, *the Clock,*		24
34. Cela Sculptoria, *the Engraver's Tools,*		19
35. Columba Noachi, *Noah's Dove,*		52
36. Equuleus Pictoris, *the Painter's Easel,*		22
37. Dorado, *the Sword Fish,*		19
38. Piscis Volans, *the Flying Fish,*		12
39. Argo Navis, *the Ship Argo,*	Canopus, 1.	64
40. Robur Carolinum, *the Royal Oak,*		12
41. Chamœleon, *the Chameleon,*		26
42. Musea Australis, *the Southern Fly,*		
43. Apus, *the Bird of Paradise,*		13
44. Octans, *the Octant,*		34
45. Hydrus, *the Water Snake,*		24
46. Reticulum Rhomboidum, *the Rhomboidal Net,*		15
47. Mons Mensæ, *the Table Mountain,*		13

ECLIPSES.

An eclipse of the sun is occasioned by the moon coming between the earth and the sun, so as to intercept his light, that to any place of the earth the sun may appear partly or wholly covered. This privation of the sun's light is nothing more than the moon's shadow falling on the earth at the place of observation; hence, all solar eclipses happen at the time of new moon.* An eclipse of the moon is occasioned by the earth coming between the sun and the moon, so as to deprive her of the sun's light, or by the moon entering into the earth's shadow;† hence, all lunar eclipses

*Let S represent the sun. (Plate 3, Fig. 2.) E the earth, and M the moon between the sun and the earth. The dark conical shadow *a b c* of the moon, is called the umbra, and this umbra can cover no more than a portion of the earth's surface, about 180 miles in extent. The bright or partial shadow *a d b e*, of the moon, is called the penumbra, which may cover a circular space on the earth of 4900 miles in diameter. (See Ferguson's Astronomy, Art. 334.) A *c* on the earth's surface, where the umbra falls, the eclipse will be total; and at *e*, *d*, where the penumbra falls, there will be a partial eclipse; but, at all other places on which the penumbra does not fall, there will be no eclipse.

†Let M represent the moon in opposition to the sun. (Plate 3. Fig. 2.) and *f g h i* the earth's shadow. The moon M will be eclipsed as long as she continues in the earth's shadow, and the eclipse will be visible to every part of that hemisphere of the earth which is turned next her.

must happen when the moon is in opposition to the sun, or at the time of full moon. When the sun is eclipsed to us, the earth as a moon will be partly eclipsed to the moon, and the inhabitants of the moon (if there be any,) may see her shadow pass over the earth like a dark circle. When an eclipse of the moon happens, the sun will be eclipsed to her, as long as she continues in the earth's shadow.

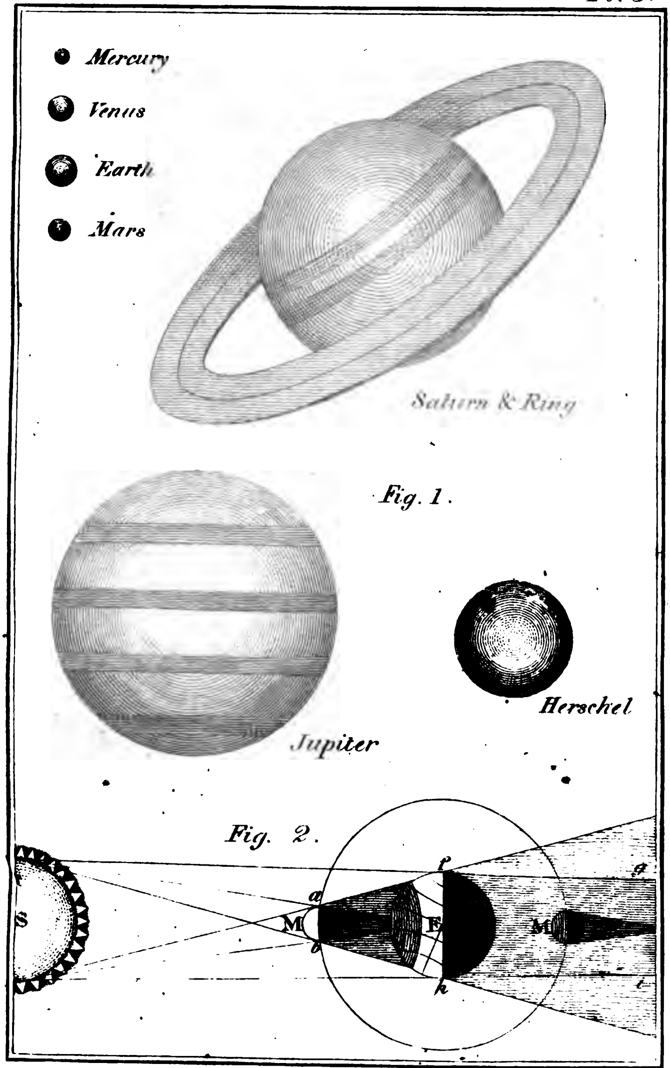
If the moon's orbit were in the plane of the earth's orbit, the moon's shadow would fall upon the earth at every new moon, and cause an eclipse of the sun; and the moon would pass through the middle of the earth's shadow and be eclipsed, at every full moon. But the moon's orbit is inclined to that of the earth in an angle of about 5¼ degrees, and intersects it in two points called the moon's nodes. Astronomers have calculated, that when the moon changes at more than 17 degrees from either node, she is then either too high or too low in her orbit to cast her shadow upon the earth, and consequently there can be no eclipse of the sun; but if the moon be less than 17 degrees from either node at the change, her shadow may fall upon the earth, and the sun be eclipsed. It is also determined, that when the moon is more than 12 degrees from either node at the time of full moon, she is then either too high or too low in her orbit to pass through any part of the earth's shadow, and consequently she will not undergo an eclipse; but if the moon be less than 12 degress from either node at the full, she may be eclipsed.

When the moon changes at her least distance from the earth, and within the ecliptic limits of the sun, she appears large enough to cover the whole disc of the sun from those places of the earth on which her dark shadow falls: and consequently, the sun will be totally eclipsed there. But when the moon changes at her greatest distance from the earth, and within the sun's ecliptic limits, she appears less than the sun, and therefore cannot cover his whole disc from any part of the

earth; and, at that place of the earth, which is in a di-direct line between the centres of the sun and moon, a person would see the edge of the sun round the dark body of the moon, appearing like a luminous ring, called an *annular* eclipse. The sun's apparent diameter when smallest is 31′ 29″, and the moon's when largest 33′ 34″; therefore, the total darkness in the greatest solar eclipse that can happen, will only continue 4 minutes, 6 seconds, which is the time that the moon takes to move in her orbit over 2′ 5″, the difference between the moon's greatest and the sun's least apparent diameter. An eclipse of the sun begins on his western edge, and ends on the eastern; and an eclipse of the moon begins on the eastern edge of her disc, and ends on the western.

The sun's ecliptic limits are greater than the moon's, consequently there will be more solar than lunar eclipses; yet there are more visible eclipses of the moon than of the sun, because lunar eclipses are visible to every part of that hemisphere of the earth, which is turned next her, at the same time; but a solar eclipse is only visible to that part of the earth on which the moon's shadow falls.

Pl. 3.



J. Sands Sc.

PROBLEMS

PERFORMED BY

THE TERRESTRIAL GLOBE.

PROBLEM I.

Any place being given, to find its latitude, and all those places which have the same latitude.

RULE.

Find the place on the globe, and bring it to that part of the brass meridian which is numbered from the equator towards the poles, the degree above it is its latitude north or south, according as the place is on the north or south side of the equator. Turn the globe round on its axis, and all places that pass under the degree on the brass meridian, which is the latitude of the given place, are those which have the same latitude.

EXAMPLES.

1. What is the latitude of Constantinople?

Ans. 41 degrees North.

2. Required the latitude of Petersburg?

3. What places have the same, or nearly the same latitude as Philadelphia?

Ans. Pekin, Naples, Constantinople, Madrid, &c.

4. The length of the longest day at Bergen is 19 hours; required those places* which have the longest day the same length.

5. What inhabitants of the earth have the same length of days as the inhabitants of Havana?

6. Where are the seasons of the year the same as at Boston?

7. Find the latitudes of the following places, and all those places which have the same latitudes:

Berlin	Madrass	Paris	Washington
Hamburgh	Archangel	Mecca	Mexico
Lisbon	Naples	Cairo	Quebec.

8. What is the greatest latitude that a place can have?

PROBLEM II.

Any place being given to find its longitude, and all those places which have the same longitude.

RULE.

Find the place on the globe and bring it to the brass meridian, the number of degrees on the equator, counting from the first meridian to the brass meridian, is the longitude. If the given place lie to the right hand of the first meridian the longitude is east; if to the left hand the longitude is west;† and all places under the same edge of the brass meridian from pole to pole have the same longitude.

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* All places in the same latitude have the same length of day and night, and the same seasons of the year, though they may not have the same atmospherical temperature.

† The learner should stand with his face toward the North Pole.

EXAMPLES.

1. What is the longitude of Pondicherry?

Ans. 80 degrees east.

2. What places have the same, or nearly the same longitude as Rome?

Ans. Leipsic, Tripoli, Wittenburg, &c.

3. When it is nine o'clock in the morning at Washington, what inhabitants* of the earth have the same hour?

4. What inhabitants of the earth have midnight, when it is midnight at London?

5. What inhabitants of the earth have noon, when those of Baltimore have noon?

6. Find the longitudes of the following places, and all those places which have the same longitudes:

New-York	Quito	Nankin
New-Orleans	Leghorn	Bombay
Copenhagen	Palermo	Aberdeen
Archangel	Canton	The Sandwich Islands

7. What is the greatest longitude that a place can have?

PROBLEM III.

Any place being given, to find its latitude and longitude.†

RULE.

Bring the given place to that part of the brass meri-

*Those people who inhabit the earth under the same meridian from 66° 28′ north latitude, to 66° 28′ south latitude, have noon at the same time: and whatever be the hour of the day at any particular place, it will be the same hour at every other place situated under the same meridian.

†The first and second problems include this one, which serves only as a repetition of them.

dian, which is numbered from the equator towards the poles; the degree above it is the latitude, and the degree on the equator, cut by the brass meridian, is the longitude.

EXAMPLES.

1. What is the latitude and longitude of Moscow?
Ans. Lat. 55¾ degrees N. lon. 37½ degrees E.
2. What is the latitude and longitude of Mexico?
3. Find the latitude and longitudes of the following places:

Algiers	Bagdad	Kingston	Oporto
Amsterdam	Cadiz	Vera Cruz	Athens
Aleppo	Botany Bay	Juan Fernandez	Jaffa

PROBLEM IV.

The latitude and longitude of any place being given to find that place.

RULE.

Find the given longitude on the equator, and bring it to the brass meridian; then under the given latitude on the brass meridian, you will find the place required.

EXAMPLES.

1. What place has 155¾ degrees west longitude, and 19 degrees north latitude?
Ans. The north end of the island O-why-hee.
2. What place has 113 degrees east longitude, and 23 degrees north latitude?
3. Find those places which have the following latitudes and longitudes:

LAT.			LON.			LAT.			LON.		
60°	23′	N.	5°	12′	E.	3°	15′	S.	107°	10′	E.
22	35	N.	88	29	E	30	10	N.	81	34	W.
18	57	N.	72	31	E.	55	58	S.	67	26	W.
34	35	S.	58	31	W.	29	2	S.	168	10	E.

PROBLEM V.

To find the difference of latitude between any two places.

RULE.

Find the latitudes of both places by (Problem I.) then, if the latitudes be both north or both south, their difference will be the difference of latitude; but, if the latitudes be one north and the other south, their sum will be the difference of latitude.

EXAMPLES.

1. What is the difference of latitude between Glasgow and Boston?

Ans. 13½ degrees.

2. What is the difference of latitude between the Cape of Good Hope and Philadelphia?

3. How many degrees is Cape Horn south of Cape Verd?

4. Where must those places be situated, which have no difference of latitude?

5. What two places on the globe have the greatest difference of latitude?

6. Required the difference of latitude between the following places:

Cape Blanco and St. Matthew's Island.

Cape Guardafui and Cape St. Mary.

Martinico Island and the Island of Bermuda.

Charleston and Halifax.
Porto Bello and New-Orleans.
St. Helena and Cape Farewell.

PROBLEM VI.

To find the difference of longitude between any two places.

RULE.

Find the longitudes of both places (by Prob II.) then, if the longitudes be both east or both west, their difference will be the difference of longitude; but, if the longitudes be one east and the other west, their sum will be the difference of longitude, if it does not exceed 180 degrees; if their sum exceeds 180 degrees, take it from 360 degrees, and the remainder will be the difference of longitude.

EXAMPLES.

1. What is the difference of longitude between New-York and Oporto?

Ans. 65¾ degrees.

2. Find the difference of longitude between Archangel and London

3. How many degrees is Leghorn east of Baltimore?

4. What is the difference of longitude between Harvey's Island and Siam?

5. What is the greatest number of degrees, that one place can be east or west of another?

6. Required the difference of longitude between the following places

Fez and the Island of Bourbon.
Ascension Island and the Island of Candy.
Jeddo and Acapulco.

Cape Cod and the Island of Madeira.
Botany Bay and Gough's Island.
Washington and Rochelle.

PROBLEM VII.

*To find the distance between any two places.**

RULE.

The shortest distance between any two places on the earth is an arc of a great circle intercepted between them. Therefore, lay the graduated edge of the quadrant of altitude over the two places, so that the division

*Though this problem is very simple in theory, yet, when we apply it to practice, the difficulties which arise are insurmountable. When sailing along the trackless ocean, or travelling through unknown deserts, our only guide is the mariner's compass, and unless the two places be situated on the same meridian, or on the equator, we never can take the shortest rout, guided by the compass, as measured by the quadrant, or found by spherical trigonometry.

For example: first, let it be required to find the shortest distance between Cape Henry and Cape St. Vincent, situated on the same parallel of latitude, and differing in longitude 67°. The shortest distance found by spherical trigonometry, is an arc of a great circle containing 52° 18′, =3138 geographical miles; but if a ship take her departure from Cape St. Vincent, latitude 37 degrees north, and steer due west till her difference of longitude be 67 degrees, which will bring her to Cape Henry, her true distance sailed will be 3210¼ geographical miles, making a circuitous course of 72¼ geographical miles. Now to conduct a ship on the arc of a great circle intercepted between the above mentioned places, she must be steered through all the different angles, infinite in number, from N. 68° 17′ W. to 90°, and from thence through all the same variety of angles, till she arrives where the angle will be 68° 17′, the same as that first, which is impracticable.

Secondly. Let us take another example, in which the two places differ in latitude: suppose the Island Madeira, latitude

marked 0 may be on one of the places; the degrees on the quadrant comprehended between the two places will be their distance in degrees, which multiply by 60 for their distance in geographical miles, or by 69½ for their distance in English miles.

Or, extend a pair of compasses between the two places, apply that extent to the equator, and it will show how many degrees it contains, which multiply as above for the distance in miles.

If the distance between the two places exceed the length of the quadrant, stretch a thread between them, and mark their distance; apply this distance to the equator and it will shew the number of degrees between the two places.

EXAMPLES.

1. What is the direct distance between St. Helena and St. Salvador?

Ans. 32 degrees, =1920 geographical miles, or 2224 English miles.

32° 38′ N. longitude, 17° 6′ W. and the Island Trinidad, latitude 10° 45′ N. longitude, 60° 36′ W. The arc of a great circle contained between the two places, truly calculated by spherical trigonometry, will be 45° 31′, =2731 geographical miles; and, in order that a ship may sail on this circle, she must steer from Madeira, S. 71° 27′ W. and fluctuate in her course till she arrives at Trinidad, where the course will have gradually decreased to S. 54° 12′ W. which, though true in theory, is impracticable. Therefore, the course and distance must be found by middle latitude or Mercator's sailing. The course will be found to be S. 61° 23′ W. and distance on that course, 2741½ geographical miles, making a difference of 10½ geographical miles.

Hence, it is evident that we never can travel or sail on an arc of a great circle, guided by the compass, except on a meridian or on the equator; consequently, if the two places be otherwise situated, the distance between them, and the point of the compass on which a person must sail or travel from the one place to the other, must be found by middle latitude or Mercator's sailing.

2. What is the breadth of South America from Cape St. Roque to Cape Blanco?

3. What is the length of Africa from Cape Bon to the Cape of Good Hope?

4. What is the extent of Africa in English miles from Cape Verd to Cape Guardafui?

5. What is the direct distance between Cape Horn and the Cape of Good Hope?

6. What is the extent of Europe in English miles from the North Cape to Cape Matapan?

7. What is the shortest distance between Cape Cod and the Island Bermuda?

8. What is the extent of the Atlantic Ocean from Cape Lookout to Cape Finistierre?

9. How many miles is Africa broader than South America, where crossed by the equator?

PROBLEM VIII.

A place being given to find all those places which are situated at the same distance from it as any other given place.

RULE.

Place the division marked 0 of the quadrant of altitude on the first given place, and the graduated edge over the other, then observe the degree on the quadrant over the other place, move the quadrant entirely round, keeping the division marked 0 in its first situation, and all places which pass under the same degree which was observed to stand over the other place, are those required.

Or, take the distance between the two places in a pair of compasses, and with the first place as a centre, describe a circle; then all places situated in the circumference of this circle, are those required.

When the distance between the two places exceeds the length of the quadrant, or the extent of the compasses, stretch a thread between them, and mark their distance, with which proceed as with the quadrant.

EXAMPLES.

1. What places are situated at the same distance from London as Warsaw is?

Ans. Alicant, Buda, Koningsburg, &c.

2. What places are at the same distance from Moscow as Stockholm is?

3. What islands are situated at the same distance from the Canary Islands as Cape Verd Islands are?

4. What places are situated at the same distance from New-York as Madras is?

PROBLEM IX.

Given the latitude of a place and its distance from a given place, to find that place whereof the latitude is given.

RULE.

If the distance be given in miles, turn them into degrees, by dividing by 60 for geographical miles, or by 69½ for English miles; then place 0 of the quadrant of altitude on the given place, and move the other end eastward or westward* (according as the required place lies

*It is necessary to mention whether the place sought lie to the east or west of the given place, because the degrees of distance on the quadrant will cut the parallel of latitude in two points, viz. one east of the given place, and the other west of it.

to the east or west of the given place,) till the degrees of distance on the quadrant and parallel of latitude intersect; under the point of intersection you will find the place required.

EXAMPLES.

1. A place in latitude 13 degrees N. is 4239½ English miles from London, and is situated in west longitude; required the place?

Ans. 4239½ divided by 69½ gives 61 degrees; then 0 of the quadrant placed on London, the 61st degree of the quadrant will intersect the parallel of 13 degrees N. in west longitude, over the Island of Barbadoes, the place required.

2. What place east of Bermuda, and latitude 16 degrees S. is 4410 geographical miles from it?

3. A place in latitude 51½ degrees N. and east of Philadelphia is 3120 geographical miles from it; required the place?

4. Petersburg is 1740 geographical miles distant from two places situated on the parallel of 40 degrees N.; required the two places?

PROBLEM X.

Given the longitude of a place and its distance from a given place, to find that place whereof the longitude is given.

RULE.

If the distance be given in miles, turn them into degrees, as in the preceding problem; then, place that part of the quadrant of altitude which is marked 0 upon the given place, and move the other end northward or south-

ward,* (according as the required place lies to the north or south of the given place,) till the degrees of distance on the quadrant, and the given meridian of longitude intersect; under the point of intersection you will find the place required.

EXAMPLES.

1. A place in 75 degrees west longitude, and situated south of Dublin, is 2820 geographical miles from it; required the place?

Ans. 2820 divided by 60 will give 47 degrees, then 0 of the quadrant placed on Dublin, the 47th degree of the quadrant will intersect the meridian of 75 degrees W. south of Dublin, over Philadelphia, the place required.

2. What place north of Madrid, and longitude 30 degrees east, is 2015½ English miles from it?

3. What place south of Washington, and longitude 16½ degrees W. is 3060 geographical miles from it?

4. A place in 64½ degrees west longitude, and situated south of Lisbon, is 3058 English miles from it; required the place?

PROBLEM XI.

To find the bearing of one place from another.

RULE.

If both places be situated on the same parallel of latitude, their bearing is either east or west from each oth-

*It is necessary to mention whether the places sought lie to the north or south of the given place, because the degrees of distance on the quadrant may cut the given longitude in two points, viz. the one northward of the given place and the other southward of it.

er; if they be situated on the same meridian, they bear north and south from each other; if they be situated on the same rhumb-line, that rhumb-line is their bearing; if they be not situated on the same rhumb-line, lay the quadrant of altitude over the two places, and that rhumb-line which is the nearest of being parallel to the quadrant, will be their bearing.

If the globe have no rhumb-lines* drawn on it, apply the centre of a small mariner's compass to any given place, so that the north and south points thereof may coincide with some meridian; the other points of the compass will show the bearing of all the circumjacent places nearly.

EXAMPLES.

1. Required the bearing between Cape Hatteras and the island of Porto Rico?

Ans. S. S. E. ¼ E.

2. On what point of the compass must a ship steer from Cape Sable to Bermuda?

3. Required the bearing between the Lizard and the island of St. Mary, one of the Western Islands?

4. Which way must a ship steer from Ascension Island to St. Helena?

5. Required the bearing between Washington and the following places:

Philadelphia	Albany	Savannah	New-Orleans
Boston	Pittsburg	Nashville	Charleston
St. Augustine	Vincennes	Natches	New-York.

*There are no rhumb-lines drawn on either Cary's or Bardin's globes.

PROBLEM XII.

To find the angle of position between two places.*

RULE.

Bring one of the places to the brass meridian, and observe its latitude; elevate the north or south pole,

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* Some imagine that the angle of position represents the true bearing of one place from another, while others contend, that the one is very different from the other. Let us endeavor to examine both more minutely, and thence draw the conclusion.

By attending to the rule for finding the angle of position, as laid down in this problem, we shall find that, that part of the quadrant of altitude, intercepted between the two places, always forms the base of a spherical triangle, and the compliments of the latitudes of the two places, the two sides; also the difference of longitude is the vertical angle. The angles at the base of this triangle are the angles of position between the two places.

1. Let two places be situated in the same latitude, suppose 37 degrees north, and differing in longitude 67 degrees, which will correspond with Cape Henry and Cape St. Vincent. Now conceive a triangle on the globe formed by the co-latitudes of the two places, and that part of the quadrant of altitude between them. In this triangle, we have two sides and the included angle given, to find the base, and the angles at the base; the angles will be found to be each 68° 17′ the triangle being isosceles, and the base 52° 18′. Now if an indefinite number of points be assumed along the base, the angle of position between Cape St. Vincent and each of these points will be N. 68° 17′ W. but were it possible for a ship to sail along this arc, (see the note to Prob. VII.) by the compass, she must fluctuate in her course from N. 68° 17′ W. to 90 degrees, and from thence continue sailing through the same variety of angles, till her course becomes 68° 17′; but for a ship to sail from Cape St. Vincent N. 68° 17′ W. she would never arrive at Cape Henry, because her true course by the mariner's compass from Cape St. Vincent, along the parallel of 37 degrees north, to Cape Henry, is invariably west.

2. Let two places be taken, differing in latitudes and longitudes; suppose the island of Madeira, latitude 32° 38′ N. longitude 17° 6′ W. and the island of Trinidad latitude 10° 45′ N.

according as the latitude is north or south, so many degrees above the horizon as are equal to that latitude; screw the quadrant of altitude upon the brass meridian over that place, and move the quadrant till its graduated edge comes over the other place; then the number of degrees on the wooden horizon, between the graduated edge of the quadrant and the brass meridian, counting towards the elevated pole, will be the angle of position between the two places.

EXAMPLES.

1. What is the angle of position between Philadelphia and Paris?

Ans. 52 degrees from the north towards the east.

2. What is the angle of position between Paris and Philadelphia?

3. What is the angle of position between Washington and Rome?

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longitude 60° 36′ W. The angle of position between M. and T. calculated by spherical trigonometry, is S. 71° 27′ W. and the angle of position between T. and M. is N. 54° 21′ E. Now if we assume any number of points on the arc of a great circle between the two places, the angle of position between M. and each of those points will be invariably 71° 27′; whereas the angle of position between each point (beginning with that next to M.) and M. is continually decreasing, till it becomes 54° 21′; but the direct course from M. to T. (found by Mercator's sailing) is S. 61° 23′ W. and from T. to M. N. 61° 23′ E. Therefore if a ship were to sail from M. S. 71° 27′ W. by the compass, she would never arrive at T. and were she to sail from T. N. 54° 21′ E. she would never arrive at M.

Corollary 1. If the two places be on the equator, the angle of position between each place and all the assumed points between it and the other, will be 90 degrees, as also between each point and each place, the same as the bearing by the compass.

Corollary 2. When the two places are situated on the same meridian, the angle of position becomes the bearing.

Hence, the angle of position between two places cannot represent their true bearing by the compass, except those places be situated on the equator, or on the same meridian.

4. What is the angle of position between New York and Naples?

5. What is the angle of position between London and Archangel?

6. Required the angles of position between Washington and the following places:

Mexico	Porto Bello	Gottenburg	Lisbon
Lima	St. Domingo	Glasgow	Warsaw
Buenos Ayres	Quito	Algiers	Athens.

PROBLEM XIII.

To find the Antœci, Periœci, and Antipodes of any place.

RULE.

For the Antœci. Bring the given place to the brass meridian, and observe its latitude, then under the same degree of latitude, in the opposite hemisphere you will find the Antœci.

For the Periœci. Bring the given place to the brass meridian, and observe its latitude, set the index of the hour circle to 12, turn the globe half round, or until the index points to the other 12; then under that degree on the brass meridian, which is the latitude of the given place, you will find the Periœci.

For the Antipodes. Bring the given place to the brass meridian and observe its latitude, set the index of the hour circle to 12, turn the globe half way round, or till the index points to the other 12; then under the same degree of latitude with the given place, but in the opposite hemisphere, you will find the Antipodes

EXAMPLES.

1. Required the Antœci, Periœci, and Antipodes of the island of Bermuda.

Ans. A place situated a little N. W. of Buenos Ayres, is the Antœci; a place in China, N. W. of Nankin, is the Periœci; and the Antipodes is the S. W. part of New Holland.

2. Required the Antœci, Periœci, and Antipodes of Washington.

3. Required the Antœci of Charleston.

4. Required the Periœci of Philadelphia.

5. What inhabitants of the earth walk diametrically opposite to those of Madrid?

6. A ship in latitude 40° S. and longitude 105 E. required her Antipodes.

PROBLEM XIV.

To find how many miles make a degree of longitude in any given parallel of latitude.

RULE.*

Lay the quadrant of altitude parallel to the equator in the given latitude between any two meridians, which

*The reasons of this rule will appear evident from the following properties.

The distance between any two meridians on the equator, is to the distance between the same meridians on any parallel of latitude, as the number of miles contained in one degree of the equator, is to the number of miles contained in one degree of that parallel of latitude; but the distance on the equator between those meridians, is to the distance on the parallel of latitude between the same meridians, as the number of degrees in that distance, is to the number of degrees of equal length in the other; therefore the number of degrees on the equator between any two meridians, is to the number of degrees of equal length between the same meridians in any parallel of latitude, as the number of geographical miles in one degree of the equator, is to the number of geographical miles in one degree of that parallel of latitude.

Thus, in the latitude of Philadelphia, the distance between two

differ in longitude 15 degrees;† multiply the number of degrees intercepted between them by 4, and the product will give the length of a degree in geographical miles, which multiply by 1.158 for English miles.

EXAMPLES.

1. How many geographical and English miles make a degree of longitude in the latitude of Constantinople?

Ans. 45⅓ geographical miles, and 52 English miles.

2. How many miles make a degree of longitude in the latitude of Washington?

3. Answer the same question as the preceding, with respect to the following places:

London	Mecca	Fez	Upsal
Edinburgh	Dublin	Tripoli	New-York
Paris	Quebec	Surinam	Petersburgh.

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meridians which differ in longitude 15 degrees, measured by the quadrant of altitude, is 11½° nearly. Then from what has been demonstrated, 15° : 11½° : : 60m. : 46m.; likewise alternately 15° : 60 : : 11½° : 46; but 15 : 60 : : 1 : 4; therefore 1 : 4 : : 11½ : 46; hence, 11½×4 = 46×1 = 46, the number of geographical miles contained in one degree of longitude in the latitude of Philadelphia. And the number of geographical miles multiplied by 1.158 will give the English miles, because 60 : 69½ : : 1 : 1.158, nearly.

When great exactness is required, recourse must be had to calculation, as shown in the note to the table annexed to this problem, because the quadrant of altitude will measure no arc truly but that of a great circle; consequently, the rule cannot be mathematically true, though sufficiently correct for all practical purposes.

† The meridians on some large globes are drawn through every 10 degrees. The rules for such globes will answer by reading 10 degrees for 15 degrees, and by multiplying by 6 instead of 4

A TABLE,

*Shewing how many miles make a degree of longitude, in every degree of latitude.**

Deg. Lat.	Geo. Miles.	Eng. Miles.	Deg. Lat.	Geo. Miles.	Eng. Miles.	Deg. Lat.	Geo. Miles.	Eng. Miles.
1	59.99	69.06	31	51.43	59.13	61	29.09	33.45
2	59.96	69.03	32	50.88	58.51	62	28.17	32.40
3	59.92	68.97	33	50.32	57.87	63	27.24	31.33
4	59.85	68.90	34	49.74	57.20	64	26.30	30.24
5	59.77	68.81	35	49.15	56.51	65	25.36	29.15
6	59.67	68.62	36	48.54	55.81	66	24.40	28.06
7	59.55	68 48	37	47.92	55.10	67	23.45	26.96
8	59.42	68.31	38	47.28	54.37	68	22.48	25.85
9	59.26	68.15	39	46.63	53.62	69	21.50	24.73
10	59 09	67.95	40	45.96	52.85	70	20.52	23.60
11	58.89	67.73	41	45.28	52.07	71	19.53	22.47
12	58.69	67.48	42	44.59	51.27	72	18.54	21.32
13	58.46	67.21	43	43.88	50.46	73	17.54	20.17
14	58.22	66.95	44	43.16	49.63	74	16.54	19.02
15	57.95	66.65	45	42.43	48.78	75	15.53	17.86
16	57.67	66.31	46	41.68	47.93	76	14.52	16.70
17	57.38	65.98	47	40.92	47.06	77	13.50	15.52
18	57.06	65.62	48	40.15	46.16	78	12.48	14.35
19	56.73	65.24	49	39.36	45.26	79	11.45	13.17
20	56.38	64.84	50	38.57	44.35	80	10.42	11.98
21	56.01	64.42	51	37.76	43.42	81	9.38	10 79
22	55.63	63.97	52	36.94	42.48	82	8.35	9.59
23	55 23	63.51	53	36.11	41.53	83	7.31	8.41
24	54.81	63.03	54	35.27	40.56	84	6.27	7.21
25	54.38	62.53	55	34.41	39.58	85	5 22	6.00
26	53.93	62.02	56	33.53	38.58	86	4.18	4.81
27	53.46	61.48	57	32.68	37.58	87	3.14	3.61
28	52.97	60.93	58	31.79	36.57	88	2.09	2.41
29	52.48	60.35	59	30.90	35.54	89	1.05	1.21
30	51.96	59.75	60	30.00	34.50	90	0.00	0.00

* The principles upon which this table is founded are as follows. The circumferences of circles are in a direct proportion to each other as their radii; and because the earth turns round once on its axis in 24 hours from west to east, every point on its surface

PROBLEM XV.

To find at what rate per hour the inhabitants of any place are carried, from west to east, by the revolution of the earth on its axis.

RULE.

Find how many miles make a degree of longitude in the latitude of the given place, (by Prob. XIV.) which multiply by 15 for the answer.*

EXAMPLES.

1. At what rate per hour are the inhabitants of Philadelphia carried, from west to east, by the revolution of the earth on its axis?

Ans. The latitude of Philadelphia is 40° N. where a degree of longitude measures 46 geographical miles, or

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will describe circles, or parallels of latitude parallel to the equator; hence, it follows that the earth's semidiameter at the equator, is to the semidiameter of any parallel of latitude, as the circumference of the equator, is to the circumference of that parallel of latitude, or as the length of one degree on the equator, is to the length of one degree on that parallel of latitude; but the semidiameter of the earth at the equator is the sine of 90 degrees, and the semidiameter of any parallel of latitude, is the sine compliment of that latitude; therefore as radius is to the sine compliment of any parallel of latitude, so is 60 geographical miles, the length of a degree on the equator, to the length of a degree in geographical miles, on that parallel of latitude. By this last proportion the table was constructed.

* The reason of this rule is evident, because 360 degrees divided by 24 will give 15, the number of degrees the inhabitants of the earth are carried in one hour; hence the number of miles contained in one degree of longitude on any parallel of latitude multiplied by 15, gives the number of miles the inhabitants are carried round in one hour, on that parallel of latitude.

52.8 English miles. Then $46 \times 15 = 690$ and $52.8 \times 15 = 792$; hence, the inhabitants of Philadelphia are carried 690 geographical miles, or 792 English miles per hour, by the revolution of the earth on its axis.

2. At what rate per hour are the inhabitants of Petersburg carried by the revolution of the earth on its axis from west to east?

3. At what rate per hour are the inhabitants of the following places carried by the revolution of the earth on its axis from west to east?

Cairo	Moscow	Buenos Ayres	Washington
Vienna	Bergen	Quito	New-York
Conception	London	Stockholm	Cadiz.

PROBLEM XVI.

The hour of the day being given at any place, to find what hour it is at any other place.

RULE.

Bring the place at which the hour is given to the brass meridian, and set the index of the hour circle to 12;* turn the globe on its axis, the nearest way, till the other place comes to the brass meridian, and the hours passed over by the index, will be the difference of time between the two places. If the place where the hour is sought lie to the east of that wherein the hour is given, the hour there is the difference of time later than the given hour; but if it lie to the west, it is the difference of time earlier.

Or, find the difference of longitude in degrees between the two places, (by Prob. VI.) which turn into time by

*It matters not what hour the index is set to, but 12 is the most convenient. On some globes the brass meridian serves as an index.

dividing by 15* for hours, and the remainder, if any, multiply by 4 for minutes. The difference of longitude in time, will be the difference of time between the two places, with which proceed as above.

Note. he rules given by some authors for the solution of problems, wherein the hour circle is used, are not general, but only answer for some particular hour circle. This rule and all succeeding ones are general, and they will answer any hour circle whatever.

EXAMPLES.

1. When it is nine o'clock in the morning at Philadelphia, what hour is it at London?

Ans. The difference of time between the two places will be found to be 5 hours; and because London lies to the east of Philadelphia, it is 5 hours, the difference of time later there; that is, it is two o'clock at London in the afternoon. Or, the difference of longitude between the two places is 75° 13', which, divided by 15, gives 5 hours, 52 seconds, the difference of time; and since London lies to the east of Philadelphia, the clocks there are 5 h. 52 sec. faster than those at Philadelphia; hence, when it is nine o'clock at Philadelphia in the morning, it is 52 seconds past two in the afternoon at London.

2. When it is eleven o'clock in the morning at Lisbon, what is the hour at Washington?

3. When it is midnight at Mexico, what hour is it at Canton?

4. When it is one o'clock in the morning at Madras, what hour of the day is it at Baltimore?

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* Because 24 is contained in 360, 15 times; therefore 15 degrees difference of longitude is equal to one hour, and consequently one degree is equal to four minutes of time.

5. How much are the clocks at New-York slower than those of Constantinople?

6. Whether are the clocks of Buenos Ayres faster or slower than those of Annapolis, and how much?

7. When it is half past ten o'clock in the afternoon at Charleston, what is the hour at Madrid?

8. My watch being well regulated when I left Amsterdam, but when I arrived at Havana, it was 5 hours and 40 minutes faster than the clocks there. How much did it gain or lose during the voyage?

9. When the sun wants 3 hours 15 minutes, of coming to the meridian of Boston, what time has elapsed since he came to the meridian of Paris on that day?

PROBLEM XVII.

The hour of the day being given at any place, to find all those places on the globe where it is any other given hour.

RULE.

Bring the given place to the brass meridian, and set the index of the hour circle to 12; then, if the hour at the required places be earlier than the hour at the given place, turn the globe on its axis eastward, till the index has passed over as many hours as are equal to the difference of time between the hour at the given place, and the hour at the required places; but if the hour at the required places be later than the hour at the given place, turn the globe westward on its axis, till the index has passed over as many hours as are equal to the same difference of time, and in each case, all the places required will be found under the brass meridian.

Or, reduce the difference of time between the hour at the given place and the hour at the required places

into degrees, by allowing 15 degrees to an hour. The difference of time in degrees, will be the difference of longitude between the given place and the required places; then, if the hour at the required places be earlier than the hour at the given place, the required places lie so many degrees to the westward of the given place as are equal to the difference of longitude; but if the hour at the required places be later than the hour at the given place, the required places lie so many degrees to the eastward of the given place as are equal to the difference of longitude.*

EXAMPLES.

1. When it is nine o'clock at Philadelphia in the morning, at what places is it half past four in the afternoon?

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*A thorough understanding of this problem and all others wherein time is concerned, depends on a correct idea of the rotation of the earth on its axis, from west to east. Let us conceive the sun fixed at an immense distance from the earth and over the meridian of Philadelphia; now, when the sun was over the meridian of any other place situated 15 degrees eastward of Philadelphia, the earth must have turned on its axis eastward 15 degrees, or the 24th part of one rotation, equal to one hour of time, to bring him to the meridian of Philadelphia; consequently when it is noon at Philadelphia, it is one hour past noon, or one o'clock at all places situated 15 degrees eastward of Philadelphia, and at all places 30 degrees eastward it is two o'clock, &c. Also, when the sun is over the meridian of those places situated 15 degrees westward of Philadelphia, the earth must have turned on its axis 15 degrees eastward, equal to one hour of time, to bring him there, since he was over the meridian of Philadelphia; consequently when it is noon at Philadelphia, it wants one hour to noon at all places situated 15 degrees westward of it, or, when it is twelve o'clock at Philadelphia, it is eleven o'clock at all places situated 15 degrees westward of it, and ten o'clock at those places situated 30 degrees westward of it, &c.

Ans. The difference of time between nine o'clock in the morning and half past four in the afternoon, is 7½ hours, and the time at the required places is later than at Philadelphia, the given place; therefore they must lie to the eastward of it. Bring Philadelphia to the brass meridian, and set the index of the hour circle to 12, then by turning the globe westward till the index has passed over 7½ hours, you bring those places to the brass meridian, which lie eastward of Philadelphia, and have the hour of the day 7½ hours later than at Philadelphia. All the places of note under the meridian are Moscow, Aleppo, &c.

Or, the difference of the time between Philadelphia and the required places, is 7 hours, 30 minutes, which multiplied by 15 produces 112° 30′, the difference of longitude between Philadelphia and the required places; and, since the hour at the required places is later than the hour at Philadelphia, the given place, they must lie 112° 30′ to the eastward of it. Hence, all places situated 112° 30′ eastward of Philadelphia, are those required, and they will be found to be Moscow, Aleppo, &c.

2. When it wants 7 minutes to one o'clock in the afternoon at Paris, where does it want a quarter to nine o'clock in the morning?

Ans. The difference of time between Paris and the required places, is 4 hours 8 minutes, and the time at the required places is earlier than that at Paris; therefore, the required places lie 4 hours 8 minutes westward of Paris. Bring Paris to the brass meridian, and set the index to 12, turn the globe on its axis eastward, because the required places lie to the westward of the given place, till the index has passed over 4 hours 8 minutes,*

* If the hour circle be not divided into parts less than a quarter of an hour, turn the globe eastward till the index has passed over 4 hours; then by turning it two degrees more to the east (reckoning on the equator) answering to 8 minutes of time, you will have the solution very exact. Or, for any number of minutes which cannot be reckoned on the hour circle, turn the globe as many degrees as will correspond with that number of minutes.

the difference of time; then all places under the brass meridian are those required, and they will be found to be Barbadoes, Falkland Islands, &c.

3. When it wants a quarter to nine o'clock in the morning at Constantinople, where is it noon?

4. When the sun comes to the meridian of Greenwich, where is it but 20 minutes past five o'clock in the morning?

5. When it is a quarter past noon at London, what inhabitants of the earth have midnight?

6. When it is 20 minutes past noon at Dublin, where is it two o'clock in the afternoon?

7. A ship in 45 degrees north latitude, and the mariners having lost all reckoning with respect to longitude, but from a correct celestial observation found it half past 10 o'clock in the morning, when it was but a quarter past nine by a good time-piece, which shows the hour at Philadelphia. Required the longitude of the ship.

8. The clocks of a certain city in the western continent, are 5 hours 11 minutes slower than the clocks of London; required that city.

PROBLEM XVIII.

To find the sun's longitude, or his place in the ecliptic, and his declination, for any given day.

RULE.

Find the given day in the circle of months on the horizon, against which, in the circle of signs, are the sign and degree in which the sun is for that day. Find the same sign and degree in the ecliptic on the globe; bring the degree thus found to that part of the brass meridian which is numbered from the equator towards the poles, the degree above it on the brass me-

ridian is the sun's declination north or south, according as it is on the north or south side of the equator.

Or, *by the Analemma.** Find the day of the month on the analemma, and bring it to that part of the brass meridian which is numbered from the equator towards the poles, the degree above it on the brass meridian is the sun's declination. Bring that part† of the ecliptic which corresponds with the day of the month, to the brass meridian, and observe, what degree of it passes under the degree of the sun's declination; that degree of the ecliptic will be the sun's longitude, or place in the ecliptic, for the given day.

EXAMPLES.

2. What is the sun's longitude and declination on the 10th of May?

Ans. The sun's longitude is 20 degrees in ♉, declination 17¾ degrees N.

2. Required the sun's place in the ecliptic and his declination on the 11th of October.

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* The analemma on the globe is a narrow strip painted on some vacant part of it, from the tropic of Cancer to the tropic of Capricorn. It is divided into two parts, by a straight line drawn through the middle from one end to the other. The right hand part commences at the winter solstice, or December 21st, and is divided into months and days of the months towards the summer solstice, or June 21st, correspondent to the sun's declination for every day in that half of the year. The left hand part commences at the summer solstice, and is divided similarly to the right hand part, towards the winter solstice. On Cary's globes the analemma resembles the figure 8, and it must have been drawn in this shape for the purpose of shewing the equation of time.

† If the sun's declination be north, a d increasing, the sun's longitude will be somewhere between Aries and Cancer, and that part of the ecliptic must be brought to the brass meridian; but if decreasing, the longitude will be between Cancer and Libra. If the sun's declination be south, and increasing, the sun's longitude will be between Libra and Capricorn; but if decreasing, the longitude will be between Capricorn and Areis.

3. Required the sun's longitude and his declination on the following days:

January 14	April 30	July 31	October 8
February 26	May 7	August 28	November 19
March 18	June 10	September 2	December 30

TABLE OF THE SUN'S DECLINATION.

Day of the month	January.		February		March.		April.		May.		June.	
1	23°	1′S.	17°	6′S	7°	35′S	4°	32′N	15°	4′N	22°	4′N
2	22	56	16	49	7	12	4	55	15	22	22	12
3	22	50	16	31	6	49	5	18	15	40	22	19
4	22	44	16	14	6	26	5	41	15	57	22	26
5	22	38	15	55	6	3	6	4	16	15	22	33
6	22	31	15	37	5	40	6	26	16	32	22	40
7	22	23	15	18	5	17	6	49	16	48	22	46
8	22	15	14	59	4	53	7	12	17	5	22	51
9	22	7	14	40	4	30	7	34	17	21	22	57
10	21	58	14	21	4	6	7	56	17	37	23	2
11	21	49	14	1	3	43	8	18	17	52	23	6
12	21	39	13	41	3	19	8	40	18	8	23	10
13	21	29	13	21	2	56	9	2	18	23	23	14
14	21	19	13	1	2	32	9	24	18	37	23	17
15	21	8	12	41	2	8	9	45	18	52	23	20
16	20	57	12	20	1	45	10	7	19	6	23	22
17	20	45	11	59	1	21	10	28	19	19	23	24
18	20	33	11	38		57	10	49	19	33	23	26
19	20	21	11	17		34	11	10	19	46	23	27
20	20	8	10	55		10	11	30	19	58	23	28
21	19	55	10	34		14 N	11	51	20	11	23	28
22	19	41	10	12		37	12	11	20	23	23	28
23	19	27	9	50	1	1	12	31	20	35	23	27
24	19	13	9	28	1	25	12	51	20	46	23	26
25	18	58	9	15	1	48	13	11	20	57	23	25
26	18	43	8	43	2	12	13	30	21	8	23	23
27	18	28	8	21	2	35	13	49	21	18	23	21
28	18	12	7	58	2	59	14	8	21	28	23	19
29	17	56			3	22	14	27	21	37	23	16
30	17	40			3	45	14	46	21	46	23	12
31	17	23			4	9			21	55		

TABLE OF THE SUN'S DECLINATION

CONTINUED.

Days of the month	July.		August.		Sept.		October.		Novemb.		Decemb.	
1	23°	9'N	18°	4'N	8°	20'N	3°	10'S	14°	26'S	21°	50'S
2	23	4	17	49	7	58	3	33	14	45	21	59
3	23	0	17	34	7	36	3	56	15	4	22	8
4	22	55	17	18	7	14	4	19	15	23	22	16
5	22	50	17	2	6	52	4	43	15	41	22	24
6	22	44	16	45	6	29	5	6	15	59	22	31
7	22	38	16	29	6	7	5	29	16	17	22	38
8	22	31	16	12	5	44	5	52	16	35	22	45
9	22	24	15	55	5	22	6	15	16	52	22	51
10	22	17	15	37	4	59	6	38	17	9	22	56
11	22	9	15	20	4	36	7	0	17	26	23	1
12	22	1	15	2	4	13	7	22	17	43	23	6
13	21	52	14	44	3	50	7	45	17	59	23	10
14	21	44	14	25	3	27	8	8	18	15	23	14
15	21	34	14	7	3	4	8	30	18	30	23	18
16	21	25	13	48	2	41	8	52	18	45	23	21
17	21	15	13	29	2	18	9	14	19	0	23	23
18	21	4	13	9	1	55	9	36	19	15	23	25
19	20	54	12	50	1	31	9	58	19	29	23	26
20	20	43	12	30	1	8	10	20	19	43	23	27
21	20	31	12	10		45	10	41	19	56	23	28
22	20	20	11	50		21	11	3	20	9	23	28
23	20	8	11	30		2 S	11	24	20	22	23	27
24	19	55	11	9		26	11	45	20	34	23	26
25	19	42	10	49		49	12	6	20	46	23	25
26	19	29	10	28	1	13	12	26	20	58	23	23
27	19	16	10	7	1	36	12	47	21	9	23	21
28	19	2	9	46	1	59	13	7	21	20	23	18
29	18	48	9	25	2	23	13	27	21	30	23	15
30	18	34	9	3	2	46	13	47	21	40	23	11
31	18	19	8	42			14	7			23	7

PROBLEM XIX.

To show the comparative lengths of the days and nights at the equinoxes, at the summer solstice, and at the winter solstice.

1. *For the Equinoxes.* At the time of the equinoxes the sun has no declination, being at that time in the equinoctial in the heavens, which is an imaginary line standing vertically over the equator on the earth; therefore, place the two poles of the globe in the horizon, and suppose the sun to be fixed at a considerable distance from the globe, in that part of the equinoctial in the heavens, which stands vertically over that part of the brass meridian which is marked 0. Now it is evident that the wooden horizon will be the boundary of light and darkness on the globe, and that the upper hemisphere will be enlightened from pole to pole.

If you bring any place to the western edge of the horizon, the meridian passing through that place, will coincide with the western semicircle of the horizon, and the sun will appear to be rising in the east to all places situated on that meridian; and to all places situated on the opposite meridian, which coincides with the eastern semicircle of the horizon, he will appear to be setting in the west; turn the globe gently on its axis towards the east, and to the different places which successively enter the enlightened hemisphere, the sun will appear to be rising, and to those which enter the dark hemisphere, he will appear to be setting. All the parallels of latitude north and south of the equator, are divided into two equal parts by the horizon; that is, all the diurnal arcs are equal to all the nocturnal arcs; therefore it follows, that in turning the globe once round on its axis from west to east, every place on its surface will be the same length of time in the enlightened hemisphere as in the dark hemisphere; conse-

quently, at the time of the equinoxes, the days and night are equal or twelve hours each all over the world.

2. *For the Summer Solstice.* The summer solstice, to the inhabitants of north latitude, happens on the 21st of June, when the sun enters Cancer, at which time his declinaton is 23° 28′ north. Elevate the north pole 23½ degrees above the north point of the horizon, bring the beginning of Cancer in the ecliptic to the brass meridian, and over that degree of the brass meridian, under which the beginning of Cancer stands, suppose the sun to be fixed at a considerable distance from the globe. While the globe remains in this position, the horizon will show the boundary of light and darkness, and to all places in the western semicircle of the horizon, the sun will appear to be rising; and to all places in the eastern semicircle of the horizon, he will appear to be setting.

The planes of all the parallels of latitude are parallel to one another, because each of them is parallel to the plane of the equator, and all these planes of circles from the Arctic circle to the Antartic circle, will be cut obliquely by the plane of the horizon, which touches the Arctic circle and diametrically opposite touches the Antartic circle, so that from the equator northward, as far as the Arctic circle, the diurnal arcs or those above the horizon, will exceed the nocturnal arcs or those below the horizon; hence, the length of the day exceeds the length of the night; and all the parallels of latitude within the Arctic circle will be wholly above the horizon; consequently, those inhabitants will have no night. From the equator southward, as far as the Antartic circle, the nocturnal arcs will exceed the diurnal arcs, so that the length of the night exceeds the length of the day; and all the parallels of latitude within the Antartic circle, will be wholly below the horizon; therefore, the inhabitants (if any) will have twilight or dark night.

If we take any parallel of latitude north of the equa-

tor, and compare it with that parallel of latitude, which is the same distance south of the equator, as it is north, we will find that the diurnal arc of the northern parallel, is equal to the nocturnal arc of the southern parallel, and the nocturnal arc of the northern parallel, equal to the diurnal arc of the southern parallel; consequently, when the inhabitants of north latitude have the longest day, those in south latitude have the longest night; and when the inhabitants of north latitude have the shortest night, those of south latitude have the shortest day. The days at the equator are always 12 hours long, because it is divided into two equal parts by the horizon, making the diurnal arc equal to the nocturnal arc.

3. *For the Winter Solstice.* The winter solstice, to the inhabitants of north latitude, happens on the 21st of December, when the sun enters Capricorn, at which time his declination is 23° 28′ south. Elevate the south pole 23½ degrees above the southern point of the horizon, bring the beginning of Capricorn to the brass meridian, and over that degree of the brass meridian under which the beginning of Capricorn stands, suppose the sun to be fixed at a considerable distance from the globe. Now, as at the summer solstice, the horizon will show the boundary of light and darkness, and to all places in the western semicircle of the horizon, the sun will appear to be rising; and to all places in the eastern semicircle of the horizon, he will appear to be setting.

From the equator southward, as far as the Antartic circle, the diurnal arcs will exceed the nocturnal arcs; hence, the length of the day exceeds the length of the night; and, all the parallels of latitude within the Antartic circle, will be wholly above the horizon; consequently. the inhabitants (if any) will have no night. From the equator northward, as far as the Arctic circle, the nocturnal arcs will exceed the diurnal arcs, so that the length of the night exceeds the length of the day;

and, all the parallels of latitude within the Artic circle, will be wholly below the horizon; therefore the inhabitants will have twilight or dark night. The inhabitants south of the equator will now have their longest day, while those north of the equator will have their shortest day.

PROBLEM XX.

To illustrate the three positions of the sphere, viz. Right, Parallel, and Oblique.

1 *For the Right Sphere.* The inhabitants of the equator have a right sphere, the north polar star appearing always in (or very near) the horizon. Place the two poles of the globe in the horizon, then the north pole will correspond with the north polar star; and all the heavenly bodies will appear to revolve round the earth from east to west, in circles parallel to the equinoctial, one half of the starry heavens will be constantly above the horizon, and the other half below, so that the stars will be visible for 12 hours, and invisible for the same space of time; and, in the course of a year, an inhabitant upon the equator may see all the stars in the heavens.

When the sun is in the equinoctial, he will be vertical to all the inhabitants on the equator, and his apparent diurnal path from east to west, will be over that line; when the sun has 10 degrees of north declination, his apparent diurnal motion will be nearly along that parallel; and, when he has arrived at the tropic of Cancer, his diurnal path in the heavens will be over that line, and he will be vertical to all the inhabitants on the earth in latitude 23° 28′ north. Now, during this apparent motion of the sun from Aries to Cancer, every place on the earth from the equator to the tropic of Cancer, will have the sun vertical, when his declination is equal to the lati

tude of that place; and, during his progress from Cancer to Libra in the ecliptic, he will be vertical to all the same places. In the same manner, the sun will be vertical to all places from the equator to the tropic of Capricorn, during his apparent motion from Libra to Capricorn; and also vertical to all the same places, during his apparent motion from Capricorn to Aries. Hence, the sun is vertical twice every year, to every place on the earth between the tropic of Cancer and the tropic of Capricorn, or to every place in the torrid zone. During one half of the year an inhabitant on the equator will see the sun due north at noon, and during the other half due south at noon. The greatest meridian altitude of the sun will be 90 degrees, and the least 66° 32′. The inhabitants on the equator have a right sphere, because the equator and all the parallels of latitude cut the horizon at right angles, and the horizon divides them into two equal parts, making equal day and night.

2. *For the Parallel Sphere.* The inhabitants of the north pole (if any) have a parallel sphere, the north polar star in the heavens appearing exactly, or very nearly, over their heads. Elevate the north pole 90 degrees above the horizon, then the equator will coincide with the horizon, and all the parallels of latitude will be parallel thereto. When the sun enters Aries, on the 20th of March, he will be seen by an inhabitant of the north pole to skim along the edge of the horizon; and as he increases in declination, he will increase in altitude, the altitude always being equal to the declination. The sun will form a kind of spiral curve from the equator or horizon, till he arrives at the tropic of Cancer, when his greatest declination is 23° 28′ equal to his greatest altitude, after which time he will gradually decrease in altitude as his declination decreases. When the sun arrives at the sign Libra, he will again appear to skim along the edge of the horizon, after which he will totally disappear, having been above the horizon for six months; consequently, the stars and planets will be in-

visible during that period. Though the inhabitants of the north pole will lose sight of the sun in a short time after the autumnal equinox, yet the twilight will continue for nearly two months, or till the sun descends 18 degrees below the horizon, after which all the stars in the northern hemisphere will become visible, and appear to have a diurnal revolution round the earth from east to west. The planets, when in any of the northern signs, will be visible.

The inhabitants under the north polar star will have the moon constantly above their horizon during 14 revolutions of the earth on its axis, and at every full moon which happens from the 23d of September to the 2Cth of March, the moon is in some of the northern signs, and consequently, visible at the north pole; for the sun being below the horizon at that time, the moon must be above it, because she is always in that sign, which is diametrically opposite to the sun at the time of full moon. When the sun is at his greatest depression below the horizon, being then in Capricorn, the moon is then at her first quarter in Aries, full in Cancer, and at her third quarter in Libra; and as the beginning of Aries is the rising point of the ecliptic, Cancer the most elevated, and Libra the setting point; it follows that the moon rises at her first quarter in Aries, is most elevated above the horizon, and full in Cancer, and sets at the beginning of Libra in her third quarter; having been visible during 14 revolutions of the earth on its axis. Thus the north pole is supplied one half of the winter time with constant moon light in the absence of the sun; and the inhabitants only lose sight of the moon from her third quarter to her first, while she gives but little light, and of course can be but of little or no use to them. The inhabitants of the north pole have a parallel sphere, because the equator coincides with the horizon, and all the parallels of latitude are parallel thereto.

3. *For the Oblique Sphere.* Elevate the north or south

pole, according as the latitude is north or south, so many degrees above the horizon as are equal to the latitude; and, if the globe be placed north and south by a compass, it will have exactly the same position, with respect to the heavens, as our earth has in that latitude; the axis of the globe will be parallel to the axis of the earth, and the north pole of the globe will point to the north polar star in the heavens. On the equator, the north polar star appears in the horizon; in ten degrees of north latitude it will be ten degrees above the horizon; in twenty degrees of north latitude it will be twenty degrees above the horizon; and so on, always increasing in altitude as the latitude increases. The plane of the wooden horizon will be parallel to the plane of the rational horizon of that latitude.

The meridian altitude of the sun may be found for any day by counting the number of degrees from the parallel in which the sun is on that day to the horizon, upon the brass meridian. Every inhabitant of the earth has an oblique sphere, except those who live upon the equator, or exactly at the poles, because the horizon cuts the equator obliquely, and has the days and nights of unequal lengths, the parallels of latitude, being divided into unequal parts by the rational horizon.

PROBLEM XXI

Any day being given, to find all those places of the earth where the sun is vertical on that day.*

RULE.

Find the sun's declination (by Prob. XVIII) for the given day; turn the globe round on its axis from west to east, and all the places on the globe, which pass under the degree of the sun's declination on the brass meridian will have the sun vertical on that day.

Or, *by the Analemma.* Find the given day on the analemma, and bring it to the brass meridian, the degree above it is the sun's declination; with which proceed as above.

EXAMPLES.

1. Find all those places of the earth where the sun is vertical on the 17th of May.

Ans. Mexico, the north part of St. Domingo, O-why-hee Island, Bombay Island, &c.

2. What inhabitants of the earth have the sun vertical on the 25th of October?

3. What inhabitants of the earth have no shadow at noon, on the 27th of April?

4. What inhabitants of the earth have the sun vertical on the following days?

June 21	March 20	August 31	January 7
Septem. 23	May 11	October 17	February 19
Decem. 21	July 29	Novem. 23	April 30.

* If it be required to find those places where the moon will be vertical on any given day, find the moon's declination for the given day, in the Nautical Almanac, and observe it on the brass meridian, all places passing under that degree of declination, will have the moon vertical, or nearly so, on the given day.

PROBLEM XXII.

The month and day of the month being given, and the hour of the day at any place, to find where the sun is vertical at that instant.

RULE.

Find the sun's declination (by Prob. XVIII.) bring the place at which the hour is given to the brass meridian, and set the index of the hour circle to 12; then if the given time be before noon, turn the globe westward, till the index has passed over as many hours as it wants of noon; but, if the given time be past noon, turn the globe eastward, till the index has passed over as many hours as it is past noon, in each case, the place exactly under the degree of the sun's declination on the brass meridian, will be that required.

EXAMPLES.

1. When it is 40 minutes past one o'clock in the afternoon at Philadelphia, on the 17th of May, where is the sun vertical.

Ans. The given time is one hour 40 minutes past noon; hence, the globe must be turned towards the east, till the index has passed over one hour 40 minutes; then under the sun's declination, you will find Mexico, the place required.

2. When it is 48 minutes past 6 o'clock in the morning at Paris, on the 24th of April, where is the sun vertical?

Ans. The given time is 5 hours 12 minutes before noon; therefore, the globe must be turned towards the west, till the index has passed over 5 hours 12 minutes; then under the sun's declination, you will find Madras, the place required.

3. When it is 45 minutes past 4 o'clock in the afternoon at Dublin, on the 24th of October, where is the sun vertical?

4. When it is 8 minutes past 4 o'clock in the afternoon at London, on the 15th of April, where is the sun vertical?

5. When it is midnight at Washington on the 26th of March, where is the sun vertical?

6. When it is noon at Baltimore on the 11th of May, where is the sun vertical?

7. When it is 50 minutes past 2 o'clock in the afternoon at London, on the 2nd of January, where is the sun vertical?

8. When it is 15 minutes past 5 o'clock in the morning, at Rome, on the 21st of June, what inhabitants of the earth have noon, but no shadow?

9. When it is 47 minutes past 7 o'clock in the morning at Washington, on the 13th of October, where is the sun vertical?

10. When it is 2 o'clock in the morning at Washington, on the 26th of May, where is the sun vertical.

PROBLEM XXIII.

The month, day, and hour of the day at any place being given, to find all those places of the earth where the sun is rising, those places where he is setting, those places that have morning twilight, and those places that evening twilight.

RULE.

Find the sun's declination (by Prob. XVIII.) and elevate the north or south pole, according as the declination is north or south, so many degrees above the horizon, as are equal to the sun's declination; bring the given place to the brass meridian, and set the index of the

hour circle to 12; then, turn the globe eastward or westward, according as the given time is past or before noon, till the index has passed over as many hours as it is past or before noon; screw the quadrant of altitude on the brass meridian over the degree of the sun's declination and let it pass between the globe and the horizon; keep the globe in this position; then, all places along the western edge of the horizon will have the sun rising; those along the eastern edge will have the sun setting; all places below the western edge of the horizon, within 18 degrees, shown, by the quadrant of altitude, will have morning twilight; and, all places below the eastern edge of the horizon, within 18 degrees, shown by the quadrant, will have evening twilight.

EXAMPLES.

1. When it is 30 minutes past 10 o'clock in the morning at Madrid, on the 17th of May, find those places that have the sun rising, those that have the sun setting, those that have morning twilight, and those that have evening twilight.

Ans. The sun is rising at Lexington in Kentucky, Port Royal in Jamaica, Carthagena in Terra Firma, &c. Setting at Batavia in Java, the eastern parts of China, &c. Morning twilight at the western parts of South America, Louisiana, &c. And evening twilight at Japan, Luzon, Borneo, &c.

2. When it is 20 minutes past 8 o'clock in the morning at New-York, on the 28th of December, where is the sun rising, setting, &c.?

3. When it is midnight on the 11th of January at Washington, where is the sun rising, &c.?

4. When it is noon at Baltimore on the 25th of April, where is the sun rising, &c.

5. When it is 8 o'clock in the afternoon at Naples, on the 21st of June, where is the sun rising, &c.

6. When it is 15 minutes past 4 o'clock in the after-

noon at Petersburg, on the 17th of November, where is the sun rising, &c.?

7. When it is 11 o'clock in the morning at London, on the 23d of September, where is the sun rising, &c.?

8. When it is noon at Washington on the 12th of November, where is the sun rising, &c.?

PROBLEM XXIV.

The month and day of the month being given, to find all those places of the earth where the sun does not set, and those places where he does not rise on the given day.

RULE.

Find the sun's declination (by Prob. XVIII.) elevate the north or south pole, according as the declination is north or south, so many degrees above the horizon as are equal to the sun's declination; turn the globe on its axis from west to east; then, to those places which do not descend below the horizon, near the elevated pole, the sun does not set on the given day;* and to those places near the depressed pole, which do not ascend above the horizon, the sun does not rise on the given day

EXAMPLES.

1. Find all those places of the earth where the sun does not set, and those where he does not rise, on the 6th of June.

*When the pole is elevated to the sun's declination, the horizon shows the boundary of light and darkness; consequently to that place which does not descend below the horizon, during one revolution of the earth on its axis, the sun does not set; and the inhabitants will have their shadows directed to every point of the compass in the course of 24 hours.

Ans. The sun's declination on the given day is $22\frac{3}{4}$ degrees North. Elevate the north pole $22\frac{3}{4}$ degrees above the horizon, turn the globe round, and all places within $22\frac{3}{4}$ degrees of the north pole, will not descend below the horizon; therefore, the inhabitants of those places will have constant day, or to them the sun does not set (being constantly above their horizon) for several revolutions of the earth on its axis. And, because the north pole is elevated $22\frac{3}{4}$ degrees above the horizon, the south pole is necessarily depressed $22\frac{3}{4}$ degrees below the horizon; consequently, to the inhabitants of those places within $22\frac{3}{4}$ degrees of the south pole (if there be any such inhabitants) the sun will not rise for several revolutions of the earth on its axis.

2. Find all those places where the inhabitants have constant day on the 20th of July, and those places to which the sun does not rise.

3. Does the sun shine over the north pole on the 20th of May? And to what inhabitants is he constantly visible for several revolutions of the earth on its axis?

4. What inhabitants of the earth have their shadows directed to every point of the compass, during a revolution of the earth on its axis, on the 13th of June?

5. How far does the sun shine over the south pole on the 4th of January? And what places are in perpetual darkness?

6. Is the sun visible at the North Cape on the 21st of November?

7. How far does the sun shine over the north pole on the 18th of April?

8. Is the sun visible in 75 degrees south latitude on the 20th of May?

PROBLEM XXV.

Any day beeween the 20th of March and 21st of June, or between the 23d of September and the 21st of December being given, to find those places at which the sun begins to shine constantly without setting, and those places at which he begins to be totally absent.

RULE.

Find the sun's declination (by Prob. XVIII.) count on the brass meridian from the north or south pole, according as the declination is north or south, as many degrees as are equal to the sun's declination. and observe the degree where the reckoning ends; turn the globe round on its axis, and all places passing under that degree, are those at which the sun begins to shine constantly without setting at that time; and all places that pass under the same number of degrees from the opposite pole, are those at which the sun begins to be totally absent.

EXAMPLES.

1. At what places does the sun begin to shine constantly without setting, during several revolutions of the earth on its axis, on the 17th of May; and at what places does he begin to be totally absent on the same day?

Ans. The sun's declination is 19½ degrees N. hence at all places in latitude 70½ degrees N. the sun begins to shine constantly without setting, viz. at Waygate Island in Davis's Straits, at Fisher's Island, &c. and in latitude 70½ S. he begins to be totally absent.

2. In what latitude does the sun begin to shine constantly without setting on the 7th of November, and at what places does he begin to be totally absent?

3. In what latitude does the sun begin to shine without setting on the 27th of April, and in what latitude is he beginning to be totally absent?

4. At what place is the sun beginning to be totally absent on the 14th of November?

5. Where does constant day commence on the 16th of April, and in what latitude does constant twilight or darkness begin?

6. At what place does the sun begin to shine without setting on the 3d of June?

PROBLEM XXVI.

Any place in the torrid zone being given, to find on what two days of the year the sun will be vertical at that place.

RULE.

Find the latitude of the given place (by Prob. I.) turn the globe on its axis, and observe what two points of the ecliptic pass under that degree of latitude on the brass meridian, find those points of the ecliptic in the circle of signs, on the horizon, and exactly against them, in the circle of months, stand the days required.

Or, *by the Analemma.* Find the latitude of the given place, and bring the analemma to the brass meridian, upon which, exactly under the latitude, will be found the two days required.

EXAMPLES.

1. On what two days of the year will the sun be vertical at Mexico?

Ans. On the 17th of May, and on the 25th of July.

2. On what two days of the year will the sun be vertical at Lima?

3. On what two days of the year will the sun be vortical at Madrass?

4. On what two days of the year will the sun be vertical at the following places?

Cambodia	St. Helena	Paraibo	Carthagena
Bombay I.	St. Matthew's I.	O-why-hee	Kingston
Batavia	Gondar	Quito	Domingo

PROBLEM XXVII.

To find the time of the sun's rising and setting, and the length of the day and night at any place.*

RULE†

Find the sun's declination (by Prob. XVIII.) and elevate the north or south pole, according as the declination

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*The length of the longest or shortest day at any place not in the frigid zones, may be found: for the longest day in north latitude is on the 21st of June, and the shortest on the 21st of December; and the longest day in south latitude is on the 21st of December, and the shortest on the 21st of June.

† From the following observations, the reason of these rules is obvious.

1. When this pole is elevated for the sun's declination, the sun is supposed to be fixed, and the earth to move on its axis from west to east: the horizon shows the boundary of light and darkness. Turn the globe on its axis till any place comes to the brass meridian, then at that place it will be noon; continue the motion of the globe till the same place comes to the eastern edge of the horizon, then at that place the sun will be setting; hence the number of hours passed over by the index, from the time that that place was at the brass meridian, till it came to the eastern edge of the horizon, is the number of hours elapsed from noon at that place, till sunset at the same place, that is the time of the sun's setting; if the same place be brought to the western edge of the horizon, then at that place the sun will be rising; and in turning the globe round, the index will have passed over as many hours, when that place comes to the brass meridian, as it will

is north or south, as many degrees above the horizon as are equal to the sun's declination; bring the given place

pass over from the time that the same place leaves the brass meridian, till it comes to the eastern edge of the horizon; because the arcs of the parallels of latitude above the horizon, are bisected by the brass meridian; hence the sun rises the same number of hours before noon that he sets after noon; consequently, the time of the sun's setting deducted from 12 gives the time of his rising; and, double the time of the sun's setting gives the length of the day. And, since the sun sets the same number of hours after noon that he rises before noon, he must necessarily set the same number of hours before midnight, that he rises after midnight; so that double the time of the sun's rising gives the length of the night.

2. When the pole is elevated for the latitude of the place, the earth is supposed to be fixed and the sun to move round it from east to west. Bring any place to the brass meridian, and elevate the pole for its latitude, then the wooden horizon is the true rational horizon of that place. Now, if we suppose the sun to move from east to west along that parallel of latitude which passes through his place in the ecliptic, he will be rising at that place which we brought to the brass meridian, when he enters the eastern edge of the horizon; it will be noon when he arrives at the brass meridian; and he will be setting when he enters the western edge of the horizon. And, because the brass meridian and horizon remain fixed, this supposed motion of the sun can be shown by bringing the sun's place in the ecliptic on the globe, to the eastern edge of the horizon, and turning the globe on its axis towards the west, till his place comes to the brass meridian. and to the western edge of the horizon; therefore, if the sun's place in the ecliptic for any day be brought to the brass meridian, the number of hours passed over by the index, in turning the globe round till the sun's place comes to the western edge of the horizon, will be the time of the sun's setting on that day at that place for which the globe is rectified.

3. When the pole is elevated for the latitude of the place, and the day of the month on the analemma brought to the brass meridian, the index will pass over as many hours, in turning the globe round, till the day of the month on the analemma comes to the western edge of the horizon, as it will pass over from the time that the sun's place in the ecliptic for that day leaves the brass meridian, till it comes to the western edge of the horizon; because the day of the month on the analemma, and the sun's place in the ecliptic for that day, are at the same distance from the equator, and consequently on the same parallel of latitude.

to the brass meridian, and set the index of the hour circle to 12; turn the globe eastward till the given place comes to the eastern edge of the horizon, and the number of hours passed over by the index, will be the time of the sun's setting: deduct these hours from 12, and the remainder will be the time of the sun's rising. Double the time of the sun's setting gives the length of the day, and double the time of his rising gives the length of the night.

Or, find the latitude of the given place, and elevate the north or south pole, according as the latitude is north or south, so many degrees above the horizon as are equal to the latitude: find the sun's place in the ecliptic (by Prob. XVIII.) bring it to the brass meridian, and set the index of the hour circle to 12; turn the globe westward till the sun's place come to the western edge of the horizon, and the number of hours passed over by the index will be the time of the sun's setting; with which proceed as above.

Or, *by the Analemma.* Elevate the pole for the latitude of the given place, bring the day of the month on the analemma to the brass meridian, and set the index of the hour circle to 12; turn the globe westward till the day of the month on the analemma comes to the western edge of the horizon, and the number of hours passed over by the index, will be the time of the sun's setting, &c.

Note. Of the following, viz. the time of the sun's setting, the time of his rising, the length of the day, and the length of the night; any one being given, the others may be easily obtained without the globe.

EXAMPLES.

1. At what time does the sun rise and set at Philadelphia on the 25th of May, and what is the length of the day and night.

Ans. The sunsets at a quarter past 7, and rises three quarters past 4; the length of the day is 14½ hours, and the length of the night 9½ hours.

2. At what time does the sun rise and set at Washington on the 17th of August, and what is the length of the day and night?

3. What is the length of the longest day and shortest night at New-York?

4. What is the length of the longest night and shortest day at New-York?

5. How much longer is the 21st of June at Dublin than at Baltimore?

6. How much longer is the 21st of December at Baltimore than at Dublin?

7. At what time does the sun rise and set at London on the 27th of January, and what is the length of the day and night?

8. When the sun sets at 45 minutes past 7 at any place, what is the length of the night there?

9. When the sun rises at a quarter past 4 at any place, what is the length of the day there?

10. At what time does the sun rise and set at the North Cape on the 11th of April?

11. Required the length of the longest day and shortest night at the following places:

Quebec	Charleston	Liverpool	Moscow
Boston	Quito	Belfast	Vienna
Philadelphia	Glasgow	Lisbon	Naples.

12. Required the length of the shortest day and longest night at the following places:

London	Petersburgh	Algiers	Bergen
Paris	O-why-hee	Calcutta	Falkland Islands
Catro	Otaheite	Mecca	Dublin.

PROBLEM XXVIII.

The month and the day of the month being given, at any place not in the frigid zones, to find what other day of the year is of the same length.*

RULE.

Bring the sun's place in the ecliptic for the given day (found by Prob. XVIII.) to the brass meridian and observe the degree above it; turn the globe round on its axis till some other point of the ecliptic comes under the same degree of the brass meridian; find this point of the ecliptic on the horizon, and directly against it you will find the day of the month required.

Or, any two days of the year, which are the same number of days from the longest or shortest day, are of equal length; therefore, whatever number of days the given day is before the longest or shortest day, just so many days will the required day be after the longest or shortest day, and the contrary.

Or, *by the Analemma.* Find the given day of the month on the analemma, and directly opposite to it you will find the required day of the month.

EXAMPLES.

1. What day of the year is of the same length as the 5th of May?

Ans. The 7th of August.

2. What day of the year is of the same length as the 23d of October?

3. What day of the year is of the same length as the 7th of February?

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*The same may be found for any place in the frigid zones, provided the sun rises and sets at that place on the given day.

4. What day of the year is of the same length as the 18th of August?

5. If the sun set at 12 minutes past seven o'clock at Washington on the 25th of May, on what other day of the year will he set at the same hour?

6. If the sun rise at 48 minutes past six o'clock at Philadelphia on the 30th of October, on what other day of the year will he rise at the same hour.

7. If the sun's meridian altitude at London, on the 31st of January, be 20° 53', on what other day of the year will his meridian altitude be the same?

8. If the sun's meridian altitude at Lima, on the 24th of October, be 90 degrees, on what other day of the year will his meridian altitude be the same?

PROBLEM XXIX.

To find the length of the longest day at any place in the north frigid zone.*

RULE.

Find the complement of the latitude of the given place, by subtracting its latitude from 90 degrees; count as many degrees on the brass meridian from the equator towards the north pole, as are equal to the complement of the latitude, and mark where the reckoning ends; turn the globe on its axis, and observe what two points of the ecliptic pass under the above mark, find those two points of the ecliptic in the circle of signs on the horizon, and exactly opposite to them, in the circle of months, you will find the days on which the longest

*The same may be found for the south frigid zone; but, since that zone is uninhabited, we shall confine our practice entirely to the north frigid zone.

day begins and ends. The day preceding the 21st of June is that on which the longest day begins, and the day following the 21st of June is that on which it ends; the number of days between these days will show the length of the longest day at the given place.

Or, *by the Analemma.* Count as many degrees on the brass meridian from the equator towards the north pole, as are equal to the complement of the latitude of the given place, and mark where the reckoning ends; bring the analemma to the brass meridian, and the two days which stand under the above mark, will show the beginning and end of the longest day.

EXAMPLES.

1. What is the length of the longest day at the North Cape, in latitude 71° 30′ north?

Ans. The complement of the latitude is 18° 30′; the longest day will be found to begin on the 14th of May, and end the 30th of July; therefore, the length of the longest day is 77 days, viz. the sun does not set during 77 revolutions of the earth on its axis.

2. What is the length of the longest day at Disco Island, in Baffin's Bay, in latitude 70° north?

3. What is the length of the longest day at the northern extremity of Nova Zembla?

4. What is the length of the longest day at the north pole, and on what days does it begin and end?

PROBLEM XXX.

To find the length of the longest night at any place in the nortn frigid zone.*

RULE.

Count as many degrees on the brass meridian from the equator towards the south pole, as are equal to the complement of the latitude of the given place, and mark where the reckoning ends; turn the globe on its axis, and observe what two points of the ecliptic pass under the above mark; find those points of the ecliptic in the circle of signs on the horizon, and opposite to them in the circle of months, you will find the days on which the longest night begins and ends. The day preceding the 21st of December is that on which the longest night begins. and the day following the 21st of December is that on which it ends, the number of days between these days will show the length of the longest night at the given place.

Or, *by the Analemma.* Count as many degrees on the brass meridian from the equator towards the south pole, as are equal to the complement of the latitude of the given place, and mark when the reckoning ends; bring the analemma to the brass meridian and the two days which stand under the above mark, will show the beginning and the end of the longest night.

EXAMPLES.

1. What is the length of the longest night at the North Cape, in latitude 71° 30′ north?

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*We may apply this problem to any place in the south frigid zone, were that zone inhabited.

Ans. The complement of the latitude is 18° 30′; the longest night begins on the 15th of November, and ends on the 27th of January, making it equal in length to 73 days or revolutions of the earth on its axis.

2. What is the length of the longest night at Nova Zembla, in latitude 74 degrees north?

3. On what day of the year does the sun set without rising for several revolutions of the earth on its axis, at Disco Island, latitude 70 degrees north?

4. What is the length of the longest night at the north pole, and on what days does it begin and end?

PROBLEM XXXI.

The length of the day being given at any place, to find the sun's declination, and the day of the month.

RULE.

Bring the given place to the brass meridian, and set the index of the hour circle to 12; turn the globe eastward on its axis till the index has passed over as many hours as are equal to the half length of the day; keepthe globe from revolving on its axis, and elevate or depress one of the poles, till the given place exactly coincide with the eastern edge of the horizon; the distance of the elevated pole above the horizon will be the sun's declination north or south, according as the north or south pole is elevated; find the degree of the sun's declination, thus found, on the brass meridian; turn the globe on its axis, and observe what two points of the ecliptic pass under that degree; find those points in the circle of signs on the horizon, and exactly opposite to them in the circle of months, stand the days of the months required.

Or, elevate the pole for the latitude of the place, bring any meridian on the globe to coincide with the brass meridian, and set the index to 12; turn the globe east-

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ward* till the index has passed over as many hours as are equal to the half length of the day and observe the point where the meridian, which you brought to the brass meridian, is cut by the eastern edge of the horizon; bring this point to the brass meridian, and the degree above it is the sun's declination; with which proceed as above.

Or, *by the Analemma.* Elevate the pole for the latitude of the place, bring the middle of the analemma to the brass meridian, and set the index of the hour circle to 12; turn the globe eastward till the index has passed over as many hours as are equal to the half length of the day; observe what point on the line, passing through the middle of the analemma, is cut by the eastern edge of the horizon, and exactly against this point, on either side of the analemma, will be found the day of the month required; bring the analemma to the brass meridian, and the degree above this day will be the sun's declination.

EXAMPLES.

1. What two days of the year are each 14 hours long at Philadelphia, and what is the sun's declination?

Ans. The 7th of May and the 5th of August; the sun's declination is 17 degrees north.

2. What two days of the year are each 15 hours long at London, and what is the sun's declination?

3. On what two days of the year does the sun rise at half past five o'clock at Washington?

4. What day of the year at New York is 15½ hours long?

5. What day of the year at the North Cape is one hour long?

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*The globe may be turned eastward or westward; but it will be more convenient to turn it eastward, because the brass meridian is graduated on the east side.

6. What night of the year at the North Cape is one hour long?

7. On what two days of the year does the sun rise at four o'clock at Edinburg?

8. On what two days of the year at Petersburg, is the time of the sun's rising double that of his setting; and on what two days is the time of his setting double that of his rising?

PROBLEM XXXII.

The month and day of the month being given, to find those places at which the day is a certain length.

RULE.

Find the sun's place in the ecliptic, bring it to the brass meridian, and set the index of the hour circle to 12; turn the globe westward on its axis till the index has passed over as many hours as are equal to the half length of the day; keep the globe from revolving on its axis, and elevate or depress one of the poles till the sun's place in the ecliptic comes to the western edge of the horizon; then the elevation of the pole above the horizon, will be the latitude north or south, according as the north or south pole is elevated, turn the globe on its axis, and all places passing under that latitude, will be those required.

Or, *by the Analemma.* Bring the day of the month on the analemma to the brass meridian, and proceed as above.

Note. By the above rule all those places not in the frigid zones may be found, at which the longest day is a certain length, by bringing the beginning of Cancer or Capricorn to the brass meridian, according as the longest day is on the 21st of June, or on the 21st of December, and proceeding as above.

EXAMPLES.

1. Find those places at which the 25th of May is 14½ hours long?

Ans. Philadelphia, Pekin, &c.

2. Find those places at which the 20th of November is 14 hours long.

3. At what place does the sun set at 25 minutes past seven o'clock, on the 11th of August?

4. At what place is the 21st of June 19 hours long?

5. At what place is the 21st of December 8¼ hours long?

6. At what place is the 21st of June 6¾ hours long.

7. At what place is the 21st of December 17¼ hours long?

8. In what latitude does the sun set at ten o'clock on the 3d of May?

PROBLEM XXXIII.

To find in what latitude in the north frigid zone, the longest day is a certain length.*

RULE.†

Count as many days on the horizon from the 21st of June, eastward or westward, as are equal to the half

* The same rule will answer for the south frigid zone, only count from the 21st of December.

† This problem is the reverse of the 29th, and the reason of the rule is easily understood; because the longest day at any place in the north frigid zone, begins as many days before the 21st of June, as it ends after the 21st of June; therefore, the half length of the longest day counted backwards from the 21st of June, will show the beginning of the longest day, or the day on which the sun begins to shine constantly without setting in the required latitude; now the sun's declination being found for this day; and

length of the day, and opposite to the last day, observe the sign and degree in the circle of signs; find the same sign and degree in the ecliptic on the globe, which bring to the brass meridian, and observe the degree above it; subtract the same number of degrees from 90 degrees, and the remainder will be the latitude required.

Or, *by the Analemma.* Count as many days on the analemma, from the 21st of June, as are equal to the half length of the day; bring the last day to the brass meridian, and the degree above it deducted from 90 degrees will give the latitude.

EXAMPLES.

1. In what degree of north latitude, and at what place, is the length of the longest day 77 days?

Ans. At the North Cape, in latitude 71½ degrees north?

2. At what place in the north frigid zone, does the sun shine constantly without setting; during 63 revolutions of the earth on its axis?

3. In what degree of north latitude is the longest day 120 days in length?

Note. If it be required to find in what latitude in the north frigid zone the longest night is a certain length, count as many days on the horizon from 21st of December,* eastward or westward, as are equal to the half length of the night, and proceed as in the above rule.

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subtracted from 90 degrees, will give the latitude; because when the sun's declination is north, he begins to shine constantly in that parallel of latitude, which is as many degrees from the north pole, as are equal to the declination. The half length of the longest day may be counted from the 21st of June forwards; for the sun's declination is the same as many days after the 21st of June, as it is the same number of days before the 21st of June.

*The longest night at any place in the north frigid zone begins as many days before the 21st of December, as it ends after the

4. In what latitude, and at what place in the north frigid zone, is the length of the longest night 73 days?

5. In what degree of north latitude is the length of the longest night 96 days?

6. In what degree of north latitude is the sun totally absent during 112 revolutions of the earth on its axis?

PROBLEM XXXIV.

To find the number of days on which the sun rises and sets every year, at any place in the north frigid zone.*

RULE.

Find the length of the longest day (by Prob. XXIX.) at the given place, and the length of the longest night (by Prob. XXX.) add these together and subtract their sum from 365 days, the length of the year, the remainder will show the number of days which the sun rises and sets every year at that place.

Or, *by the Analemma.* Count as many degrees upon the brass meridian on both sides of the equator as are equal to the complement of the latitude of the given place, and observe the degrees where the reckoning ends; bring the analemma to the brass meridian, and

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21st of December; therefore the half length of the longest night counted backwards from the 21st of December, will show the day on which the longest night begins, or the day on which the sun begins to be totally absent in the required latitude; find the sun's declination for this day and subtract it from 90 degrees, the remainder will be the latitude: because when the sun's declination is south, he begins to be totally absent in that parallel of latitude, which is as many degrees from the north pole, as are equal to the declination.

*This problem is equally applicable to a place in the south frigid zone.

observe what two days on the right hand side of the analemma stand under the observed degrees on the brass meridian; the time between these days (reckoning towards the north pole,) will be the number of days on which the sun rises and sets between the end of the longest night, and the beginning of the longest day; and the time between the two days on the left hand side of the analemma, which stand under the same degrees on the brass meridian, (reckoning towards the south pole) will be the number of days on which the sun rises and sets, between the end of the longest day and the beginning of the longest night. add these numbers together, and the sum will show the number of days on which the sun rises and sets every year at that place.

EXAMPLES.

1. How many days in the year does the sun rise and set at the North Cape, in latitude 71° 30′ north?

Ans. The length of the longest day found by Problem XXIX. is 77 days; the length of the longest night, found by Problem XXX. is 73 days; their sum is 150, which, deducted from 365, leaves 215, the number of days on which the sun rises and sets.

Or, *by the Analemma*, you will find the longest night to end on the 27th of January, and the longest day to begin on the 14th of May; the time between these days is 107 days, on which the sun rises and sets; and the longest day will be found to end on the 30th of July, and the longest night to begin on the 15th of November; the time between those days is 108 days, on which the sun rises and sets; consequently, the whole time of the sun's rising and setting in the year is 215 days as above.

2. How many days in the year does the sun rise and set at Disco Island, in Baffin's Bay, latitude 70 degrees north?

3. How many days in the year does the sun rise and set at the northern extremity of Nova Zembla?

4. How many days in the year does the sun rise and set at Greenland, in latitude 75 degrees north?

PROBLEM XXXV.

The month and day of the month being given at any place, to find what day following is an hour longer or shorter than the given day.

RULE.

Find the sun's declination for the given day, and elevate the pole for that declination; bring the given place to the eastern edge of the horizon, and set the index of the hour circle to 12; turn the globe eastward on its axis, if the days be increasing in length, but westward if decreasing in length, till the index has passed over half an hour, and raise or depress the pole till the place comes again to the horizon; then, the elevation of the pole in both cases, will show the sun's declination on the required day; turn the globe on its axis, and observe what degree in that part of the ecliptic, correspondent to the given day, passes under this declination, reckoned on the brass meridian towards the elevated pole; find this degree of the ecliptic on the horizon in the circle of signs, and opposite to it in the circle of months, you will find the day required.

Or, elevate the pole for the latitude of the given place, and mark the sun's declination for the given day on any meridian; bring this mark to the western edge of the horizon, and set the index to 12; turn the globe westward or eastward, according as the days are increasing or decreasing, till the index has passed over half an hour, and observe what point of the same meridian is cut by the horizon, bring that point, to the brass meri-

dian and the degree above it will show, in either case, the sun's declination, when the day is an hour longer or shorter than the given day; hence, the required day is easily obtained.

Or, *by the Analemma.* Proceed as in the above rule, only, use the day of the month on the analemma, instead of the sun's declination marked on any meridian.

Note. The day following the given day may be found, which is any given time longer or shorter than it, provided, at the given place, there is this much difference between the length of the given day, and the length of the longest or shortest day.

EXAMPLES.

1. What day following the 8th of April at Philadelphia is an hour longer?

Ans. The 3d of May.

2. What day following the 2d of July is an hour shorter than it, at New-York?

3. On what day following the 11th of September, is the sun 30 minutes later in rising than on that day, at Baltimore?

4. On what day following the 11th of September, is the sun 30 minutes earlier in rising than on that day, at Buenos Ayres?

5. What day following the 14th of July is 2 hours shorter than that day, at Edinburgh?

6. What day of the year at Petersburg, following the 24th of December, is 12 hours longer than that day at the same place?

PROBLEM XXXVI.

To find the beginning, end, and duration of twilight at any place, on any given day.

RULE.

Elevate the pole for the sun's declination on the given day, screw the quadrant of altitude on the brass meridian over the degree of the sun's declination, bring the given place to the brass meridian, and set the index of the hour circle to 12; turn the globe eastward till the given place comes to the horizon, and the hours passed over by the index will show the beginning of evening twilight; continue the motion of the globe eastward, till the given place is 18 degrees below the horizon, measured on the quadrant of altitude, and the time passed over by the index from the beginning of twilight, will show the duration of evening twilight. The morning twilight is the same length.

Or, Elevate the pole for the latitude of the given place, bring the sun's place in the ecliptic to the brass meridian, set the index to 12, and screw the quadrant of altitude on the brass meridian over the latitude of the given place; turn the globe westward on its axis, and proceed as in the above rule, only, use the sun's place in the ecliptic instead of the given place, and you will find the beginning and duration of the evening twilight.

Or, *by the Analemma.* Proceed as in the second rule, only, observe to use the given day, found on the analemma, instead of the sun's place in the ecliptic.

EXAMPLES.

1. Required the beginning, end, and duration of morning and evening twilight, at Philadelphia, on the 25th of May.

Ans. Evening twilight begins at 15 minutes past 7 and ends at 15 minutes past 9; consequently, morning twilight begins at 45 minutes past 2, and ends at 45 minuets past 4. The duration of twilight is 2 hours.

2 Required the duration of twilight at London, on the 22d of February.

3 How long does day break at Washington, before the sun rises, on the morning of the 30th of April?

4. At what time does dark night commence at Boston on the evening of June the 21st?

5. Required the beginning, end, and duration of morning and evening twilight at Dublin, on the 17th of December.

6. Required the beginning, end, and duration of morning and evening twilight at Bohemia, on the 5th of October.

PROBLEM XXXVII.

To find the beginning, end, and duration of constant day or twilight at any place.

RULE.

Add 18 degrees to the latitude of the given place; count as many degrees on the brass meridian, from the north or south pole, according as the latitude is north or south, as are equal to the sum, and observe the degree where the reckoning ends; turn the globe round on its axis, and find what two points of the ecliptic* pass under that degree; opposite those points, found on the horizon, are the two days which will show the beginning and end of constant day or twilight.

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*If the sum of the latitude and 18 degrees be less than 66° 32′, there will be no constant twilight at the given place, because this sum, counted from the north or south pole, will not reach the ecliptic.

Or, *by the Analemma.* Proceed as in the above rule, as far as, observe the degree where the reckoning ends; then, turn the globe round on its axis, and the two days on the analemma, which pass under the observed degree, will show the beginning and end of constant day or twilight.

EXAMPLES.

1. When do the inhabitants of Petersburg begin to have constant day or twilight, and how long does it continue?

Ans. The latitude of Petersburg is 60 degrees north, to which add 18 degrees, the sum is 78, which count on the brass meridian from the north pole, or 12 degrees from the equator towards the north pole, the two points of the ecliptic which pass under 12 degrees, are 2 degrees in ♉, answering to the 21st of April; and 29 degrees in ♌, answering to the 21st of August; so that the inhabitants of Petersburg, and all those who live in the same latitude, have constant day or twilight from the 21st of April to the 21st of August; that is, the sun does not descend 18 degrees below the horizon of Petersburg during that time.

2. When do the inhabitants of Archangel begin to have constant day or twilight?

3. when does constant day or twilight begin at the North Cape in Lapland, and when does it end?

4. Have ever the inhabitants of Philadelphia twilight from sun-set to sun-rise?

5. Required the beginning of constant day or twilight at Spitzbergen.

6. When does morning twilight begin at the north pole, when does evening twilight end, and how long does total darkness continue?

Ans. 18 degrees added to 90 degrees, the sum is 108, which counted from the north pole, on the brass meridian, or 18 degrees counted from the equator towards the south pole, will show the degree of the sun's decli

nation, when morning twilight begins, and when evening twilight ends; the days answering to this declination are the 28th of January, the beginning of morning twilight, and the 13th of November, the end of evening twilight, hence, the duration of morning twilight is from the 28th of January to the 20th of March, when the sun rises, being 51 days; and the duration of evening twilight is from the 23d of September, when the sun sets, to the 13th of November, being 51 days: and, the duration of total darkness is from the 13th of November to the 28th of January, being 76 days; during this period of the sun's absence and the effects of his rays, the deficiency is wonderfully supplied by the *Aurora Borealis* and the moon, which shine with uncommon splendour.

PROBLEM XXXVIII.

To find in what climate any place on the glabe is situated.

RULE.

1. If the place be not in the frigid zones, find the length of the longest day at that place (by Prob. XXVII.) and from it subtract 12 hours; the whole number of half hours in the remainder* increased by one, will show the climate.

*If there be an exact number of half hours in the remainder, that number will show the climate, at the end of which, the given place is situated, or at the beginning of the next following climate.

The general rule given by writers on the globes for finding in what climate at any place, not in the frigid zones, is situated, is to deduct 12 hours from the length of the longest day at a given place, and the number of half hours in the remainder, will show the climate. Let us prove the correctness of this rule by example. The fourth climate north of the equator ends in latitude 30°

2. If the place be in the frigid zone, find the length of the longest day at that place (by Prob. XXIX.) and if its length be less than 30 days, the place is in the 25th climate, or the first within the polar circle; if its length be more than 30 days and less than 60 days, it is in the 26th climate; if more than 60 days and less than 90 days, it is in the 27th climate, &c.

EXAMPLES.

1. In what climate is Philadelphia?

Ans. The length of the longest day at Philadelphia is 14 hours 50 minutes, from which deduct 12, the remainder will be 2 hours 50 minutes, and the whole number of half hours in this is 5, which increased by one will be 6; hence Philadelphia is in the 6th climate north of the equator.

2. In what climate is the North Cape in latitude 71½ degrees north?

3. In what climate is Washington, and what other places are situated in the same climate?

4. In what climate is Quebec,* and what other places are situated in the same climate?

5. In what climate is the north of Spitzbergen?

6. In what climate is Lima?

48′ N. and the fifth in latitude 36° 31′ N.; now, all places situated between the parallel of 30° 48′ N. and the parallel of 36° 31′ N. are in the fifth climate north of the equator; the latitude of Savannah is 32° 3′ N.; consequently, it is in the fifth climate north of the equator, and the longest day there is 14 hours 6 minutes long, from which deduct 12 hours, the remainder will be 2 hours 6 minutes, or 4 half hours; hence, Savannah is in the fourth climate; but it has been shown above to be in the fifth climate; which is absurd.

*It is to be observed, that all places situated on the same parallel of latitude, are in the same climate; but we must not infer from this that they have the same atmospherical temperature.

PROBLEM XXXIX.

To find the breadths of the several climates.

RULE.

1. *For the northern* climates between the equator and Artic circle.* Elevate the north pole 23½ degrees above the northern point of the horizon, being the beginning of Cancer to the brass meridian, and set the index of the hour circle to 12; turn the globe eastward on its axis till the index has passed over a quarter of an hour; mark with a pencil that point of the meridian passing through Libra, which is then cut by the horizon; continue the motion of the globe eastward till the index has passed over another quarter of an hour, and make another mark; proceed thus, till the meridian passing through Libra coincides with the under part of the brass meridian; bring these marks to the brass meridian, and the degree above each mark will show the latitude where each climate ends.

2. *For the climates within the north polar circle.* Find in what latitudes, in the north frigid zone, the longest day is 30, 60, 90 days, &c. long (by Prob. XXXIII.) each of these latitudes will show the latitude, where each climate within the north polar circle ends.

EXAMPLES.

1. What is the breadth of the 6th north climate, and what places are situated within it?

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*The climates south of the equator are of the same breadth as their correspondent climates north of the equator. Or, their breadths may be found in a similar manner, by elevating the south pole 23½ degrees, and bringing the beginning of Capricorn to the brass meridian, &c.

Ans. The breadth of the 6th climate is 4° 53′; it begins in latitude 36° 31′ N. and ends in latitude 41° 24′ N. and all places situated within this space, are in the same climate; we shall find them as follows; Philadelphia, Madrid, Naples, Pekin, &c.

2. What is the breadth of the 26th north climate, or the 2nd within the Artic circle?

Ans. The 26th climate begins in that latitude north, in which the length of the longest day is 30 days, and ends in that latitude north, in which the length of the longest day is 60 days; these latitudes found (by Prob. XXXIII.) will be 67° 18′ N. and 69° 33′ N.; hence, the breadth of the 26th climate is 2° 15′.

3. What is the breadth of the 9th south climate, and what places are situated within it?

4. Required the beginning, end, and breadth of the 28th climate.

TABLES OF THE CLIMATES.

1. *Climates between the Equator and the Polar Circles.*

Climates.	Ends in Lat.	Where the longest Day is.	Breadths of the Climates	Climates.	Ends in Lat.	Where the longest Day is.	Breadths of the Climates
	D. M.	H. M.	D. M.		D. M.	H. M.	D. M.
1	8 34	12 30	8 34	13	59 59	18 30	1 32
2	16 44	13 00	8 10	14	61 18	19 00	1 19
3	24 12	13 30	7 28	15	62 26	19 30	1 8
4	30 48	14 00	6 36	16	63 22	20 00	56
5	36 31	14 30	5 43	17	64 10	20 30	48
6	41 24	15 00	4 53	18	64 50	21 00	40
7	45 32	15 30	4 8	19	65 22	21 30	32
8	49 2	16 00	3 30	20	65 48	22 00	26
9	51 59	16 30	2 57	21	66 5	22 30	17
10	54 30	17 00	2 31	22	66 21	23 00	16
11	56 38	17 30	2 8	23	66 29	23 30	8
12	58 27	18 00	1 49	24	66 32	24 00	3

2. Climates between the Polar Circle and the Poles.

Climates.	Ends in Lat.	Where the longest Day is.	Breadths of the Climates	Climates	Ends in Lat	Where the longest Day is.	Breadths of the Climates
	D. M.	D. M.	D. M.		D. M.	D. M.	D. M.
25	67 18	30 or 1	46	28	77 40	120 or 4	4 35
26	69 30	60 2	2 15	29	82 50	150 5	5 19
27	73 5	90 3	3 32	30	90 00	180 6	7 1

The preceding tables may be constructed by the globe, as shown above, but not with that degree of exactness given in them; therefore, recourse must be had to calculation.*

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*1. *Construction of the first Table.*

The latitude where any climate ends between the equator and polar circles, and the ascentional difference, or the time that the sun rises before 6 o'clock in that latitude on the longest day, form the sides of a right angled spherical triangle; and the angle opposite to the latitude, is equal to the complement of the sun's greatest declination; so that, one side is given, viz. the sun's ascentional difference, and one angle, viz. the complement of the sun's greatest declination, to find the side opposite to the known angle. Hence, (by Baron Napier's rules) rad. × sine of the ascensional difference = tang. of the sun's greatest declination × tang. latitude.

Or, for the end of the 6th climate, where the sun rises 1½ hours before 6, the ascensional difference is 22° 30′, it will be,

As tangent of 23° 28′ - - - - - - -	9.63761
Is to radius, sine 90° - - - - - - -	10.00000
So is sine of the ascensional diff. 22° 30′	9.58284
To tangent latitude 41° 24′ - - - - - -	9.94523

2. *Construction of the second Table.*

Count half the length of the longest day at the end of any climate within the polar circle, from the 21st of June forward and backward; find the sun's declination answering to those two days

PROBLEM XL.

To find the sun's meridian altitude on any day at any given place.

RULE.

Elevate the pole for the latitude of the given place, find the sun's place in the ecliptic for the given day, and bring it to that part of the brass meridian, which is numbered from the equator towards the poles; then, the number of degrees on the brass meridian, reckoning from the sun's place (the nearest way) to the horizon, will be the altitude.

Or, if the latitude and sun's declination be of the same name, add the sun's declination and the complement of the latitude together, the sum will be the altitude, if it does not exceed 90 degrees; but, if this sum exceed 90 degrees, take it from 180 degrees, and the remainder will be the altitude. If the latitude and sun's declination be of different names, take the sun's declination from the complement of the latitude, and the remainder will be the altitude.

EXAMPLES.

1. What is the sun's meridian altitude at Philadelphia on the 29th of May?
Ans. 71¼ degrees.
2. What is the sun's meridian altitude at Lima on the 21st of December?

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in a table of the sun's declination; add these two declinations together, and divide the sum by 2, the qoutient is a mean declination, which take from 90 degrees, and the remainder will show the latitude where that climate ends.

3. What is the sun's greatest meridian altitude at New-Orleans?

4. What is the sun's greatest meridian altitude at Buenos Ayres?

5. What is the sun's least meridian altitude at London?

6. What is the altitude of the sun at the north pole* on the 30th of April, and what is his greatest altitude there?

Examples to be worked by Calculation.

1. What is the sun's meridian altitude at Madrid in latitude 40° 25′ N. on the 14th of August, when the sun's declination is 14° 20′ N.?

90°	00′	
40	25	latitude.
49	35	co. latitude.
14	20	declination.
53°	55′	the altitude sought.

2. What is the sun's meridian altitude at the Island of Barbadoes, in latitude 13° N. on the 7th of January, when the sun's declination is 22° 23′ south?

3. What is the sun's meridian altitude at Madras, in latitude 13° 5′ N. on the 15th of May, when the sun's declination is 18° 54′ N.?

4. What is the greatest meridian altitude of the sun at Washington, in latitude 38° 50′ N.?

*See Problem XX.

PROBLEM XLI.

To find the sun's altitude at any particular hour of the day at any place.

RULE.

Elevate the pole for the latitude of the given place, bring the sun's place in the ecliptic for the given day to the brass meridian, and set the index of the hour circle to 12; if the given time be before noon, turn the globe eastward till the index has passed over as many hours, as the given time wants of noon; but if the given time be past noon, turn the globe westward, till the index has passed over as many hours, as the given time is past noon. Keep the globe in this position, and screw the quadrant of altitude on the brass meridian over the latitude of the place; bring the graduated edge of the quadrant to coincide with the sun's place, and the number of degrees on the quadrant, between the horizon and the sun's place, will be the sun's altitude.

EXAMPLES.

1. What is the sun's altitude at Philadelphia on the 10th of May, at 10 o'clock in the morning?

Ans. 68 degrees.

2. What is the sun's altitude at Paris on the 12th of June, at 4 o'clock in the afternoon?

3. What is the sun's altitude at Moscow on the 1st of September, at half past 9 o'clock in the morning?

4. Required the sun's altitude at Porto Bello on the 9th of January, at 45 minutes past 10 o'clock in the morning?

5. What is the sun's altitude at Berlin on the 4th of July, when the sun is on the meridian at Philadelphia?

6. What is the sun's altitude at Lisbon on the 20th of March, when the sun is rising at Baltimore?

PROBLEM XLII.

To find the sun's least altitude on any day at any place in the north frigid zone, when the sun does not descend below the horizon.*

RULE.

Elevate the pole for the latitude of the place, bring the sun's place in the ecliptic to that part of the brass meridian, which is numbered from the poles toward the equator; and the number of degrees on the brass meridian, reckoning from the sun's place to the horizon, will be the altitude.

Or, from the sun's declination take the complement of the latitude, and the remainder will be the altitude.

EXAMPLES.

1. What is the sun's least altitude at the North Cape, in latitude 71½ degrees N. on the 21st of June?
Ans. 5 degrees.
2. What is the sun's least altitude at Disco Island, on the 21st of June?
3. What is the sun's least altitude at Spitzbergen in latitude 80 degrees N. on the 21st of May?
4. When it is midnight at Lisbon on the 2d of July, what is the sun's altitude at Bontekoe Island, in latitude 73½ degrees N.

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*When the sun's altitude is the least on any day at any place in the north frigid zone, it is midnight at all places in the temperate and torrid zones, situated on the same meridian as that place; and, when the sun's altitude is the greatest on any day at any place in the north frigid zone, it is noon at all places in the temperate and torrid zones, situated on the same meridian as that place. The rules to Problem XL. will serve for finding the greatest altitude.

PROBLEM XLIII.

The sun's meridian altitude and the day of the month being given, to find the latitude of the place.

RULE.

Find the sun's declination for the given day, and mark it on the brass meridian; then, if the sun was south of the observer when the altitude was taken, count on the meridian from this mark towards the south point of the horizon, as many degrees as are equal to the altitude, and observe the degree where the reckoning ends; bring this degree to coincide with the south point of the horizon, and the elevation of the pole will show the latitude north or south, according as the north or south pole is elevated. If the sun was north of the observer when the altitude was taken, count the degrees in a similar manner, from the declination towards the north point of the horizon, &c. and the elevation of the pole will show the latitude.

Or, *without the Globe* Find the zenith distance, or the complement of the altitude, which call north if the sun was south when the altitude was taken; but, if the sun was north, call the zenith distance south; find the sun's declination in a table for that purpose; then, if the zenith distance and declination have the same name, their sum is the latitude with that name; but if they have contrary names, their difference is the latitude, and of the same name with the greater.

EXAMPLES.

1. On the 10th of May, 1821, the sun's meridian altitude was observed to be 60 degrees, and it was south of the observer; what was the latitude of the place?

Ans. 47° 37 north.

By Calculation.

90° 00′
60 00 S. sun's altitude at noon.

30 00 N. the zenith distance.
17 37 N. the sun's declination 10th May, 1821.

47° 37′ N. the latitude sought.

2. On the 5th of December, 1821, the sun's meridian altitude was observed to be 80° 21′ south of the observer; required the latitude of the place.
Ans. 12° 45′ south.

By Calculation.

90° 00′
80 21 S. sun's altitude at noon.

9 39 N. the zenith distance.
22 24 S. the sun's declination 5th Dec. 1821.

12° 45′ S. the latitude sought.

3. On the 25th of May 1821, the sun's meridian altitude was observed to be 78° 13′ north of the observer; required the latitude.

4 On the 1st of February, at a certain city where the clocks are 5 hours 10 minutes slower than those at London, I observed the sun's meridian altitude to be 33° 50′ south of me; required that city.

PROBLEM XLIV.

To find the sun's amplitude at any place on any day.

RULE.

Elevate the pole for the latitude of the given place; find the sun's place in the ecliptic for the given day, and bring it to the eastern edge of the horizon; the number of degrees from the east point of the horizon to the sun's place will show the rising amplitude; bring the sun's place to the western edge of the horizon, and the number of degrees from the west point of the horizon to the sun's place will show the setting amplitude.

Or, *by the Analemma.* Elevate the pole for the latitude of the given place, and proceed as above, only use the day of the month on the analemma, instead of the sun's place in the ecliptic.

EXAMPLES.

1. What is the sun's amplitude at Philadelphia on the 16th of July?

Ans. 28 degrees from the east point towards the north, and 28 degrees from the west point towards the north.

2. What is the sun's amplitude at Washington on the 9th of November?

3. On what point of the compass does the sun rise and set at London on the 30th of April?

4. On what point of the compass does the sun rise and set at Petersburg on the 21st of June?

5. On what point of the compass does the sun rise and set at the Isle of France on the 21st of December?

6. On what point of the compass does the sun rise and set on the 20th of March?

PROBLEM XLV.

To find the sun's azimuth at any place, the day and hour being given.

RULE.

Elevate the pole for the latitude of the given place, and screw the quadrant of altitude on the brass meridian over that degree of latitude; bring the sun's place in the ecliptic to the brass meridian, and set the index of the hour circle to 12, then, if the given time be before noon, turn the globe eastward, but if after noon, westward, till the index has passed over as many hours as it is before or after noon; bring the graduated edge of the quadrant to coincide with the sun's place, then the number of degrees on the horizon, between the north or south point thereof and the graduated edge of the quadrant, will show the azimuth.

Or, *by the Analemma.* Proceed as in the above rule, only, use the day of the month on the analemma, instead of the sun's place in the ecliptic.

EXAMPLES.

1. What is the sun's azimuth at New-York on the 27th of May, at 10 o'clock in the morning?

Ans. The sun's azimuth is 63 degrees from the south towards the east?

2. What is the sun's azimuth at Paris on the 10th of November, at 3 o'clock in the afternoon?

3. What is the sun's azimuth at Washington on the 21st of June, at 6 o'clock in the morning?

4. What is the sun's azimuth at Port Royal on the 21st of June, at 7 o'clock in the morning, and at 10?*

5. At what time does the sun appear on the same azimuth, twice in the forenoon and twice in the afternoon, at Tobago Island, on the 26th of May?

6. At sea, in latitude 40 degrees N. on the 15th of March, at 8 o'clock in the morning, the sun's magnetic azimuth was observed to be S. 60° 30′ E. what was the true azimuth, and the variation of the compass?

PROBLEM XLVI.

The day of the month being given, and the sun's altitude at any place, to find the hour of the day and the sun's azimuth.

RULE.

Elevate the pole for the latitude of the given place, and screw the quadrant of altitude on the brass meridian over the degree of latitude; bring the sun's place in the ecliptic to the brass meridian, and set the index of the hour circle to 12; bring the sun's place and the degree of altitude on the quadrant to coincide; then the hours passed over by the index will show the time from noon, and the number of degrees on the horizon, between the north or south point thereof and the quadrant, will show the azimuth.

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*When the sun's declination exceeds the latitude of the place, and both of the same name, the sun will appear twice in the forenoon at different times, on the same point of the compass, and again twice in the afternoon at different times, on the same point of the compass, at that place; and, hence the shadow of an azimuth dial will go back several decrees.

EXAMPLES.

1. At what hour of the day in the afternoon,* on the 10th of November, is the sun's altitude 21 degrees at Philadelphia, and what is his azimuth?

Ans. At 48 minutes past 2, and the azimuth is 43 degrees from the south towards the west.

2. At what hour on the 11th of January is the sun's altitude 25 degrees at Washington? The observation being made in the forenoon.

3. At what hour in the afternoon on the 21st of June, is the sun's altitude 60 degrees at Constantinople, and what is his azimuth?

4. At what hour in the forenoon on the 16th of May, is the shadow of Washington Monument at Baltimore equal in length to its height? and on what point of the compass does the shadow fall?

PROBLEM XLVII.

The day of the month and the sun's amplitude being given, to find the latitude of the place of observation.

RULE.

Bring the sun's place in the ecliptic for the given day to coincide with the given degree of amplitude on the horizon, by elevating or depressing the pole; then, the elevation of the pole will show the latitude.

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* The altitude of the sun at any time before noon, is equal to his altitude at the same time past noon, at any place on any day; hence, it is requisite to mention whether the observation be made before or after noon, otherwise the problem admits of two answers.

EXAMPLES.

1. By an observation, the sun's amplitude was found to be 28 degrees from the east towards the north, on the 17th of July; required the latitude of the place.

Ans. 40 degrees N.

2. The sun's amplitude was observed to be 30½ degrees from the west towards the north, on the 13th of May; required the latitude.

3. On the 18th of January, the sun's rising amplitude was observed to be 20° 41′ from the east towards the south; required the latitude.

4. At sea, on the 23d of November, I found the sun's setting amplitude to be 32° 15′ from the west towards the south, after correcting for the variation of the compass, dip of the horizon and refraction; required the latitude the ship was in.

PROBLEM XLVIII.

Given two observed altitudes of the sun, the time elapsed between them, and the day of the month, to find the latitude of the place of observation.

RULE.

Find the sun's declination, and under the degree of that declination on the brass meridian, make a mark on the globe with a pencil; set the index to 12, turn the globe on its axis till the index has passed over as many hours as are equal to the elapsed time, and under the degree of declination on the brass meridian, make another mark on the globe; then, take the complement of the first altitude from the equator in a pair of compasses, and, with one foot in one mark, and a fine pencil in the other foot, describe an arc; take the complement of the

second altitude from the equator as before, and, with one foot in the other mark, describe an arc to cross the former arc; bring the point of intersection to the brass meridian, and the degree above it will be the latitude sought.

EXAMPLES.

1. On the 20th of May, in north latitude, at 10 o'clock in the morning, the sun's altitude was 55° 30′, and at 1 o'clock in the afternoon, his altitude was 61° 30′; required the latitude of the place.

Ans. 45 degrees north.

2. On the 21st of June, in north latitude, at 3 o'clock in the afternoon, the sun's altitude was 49° 30′, and at 5 o'clock the same afternoon, his altitude was 26 degrees; required the latitude of the place.

3. On the 23d of July, the sun's altitude was 58° 40′, and after 2 hours had elapsed, his altitude was 44 degrees; required the latitude, supposing it to be north.

4. When the sun's declination was 20 degrees S. his altitude was 35 degrees, and after 1 hour 30 minutes had elapsed, his altitude was 42 degrees; required the latitude of the place of observation, supposing it to be north.

PROBLEM XLIX.

Any place and the day of the month being given, to find at what time the sun will be due east or west.

RULE.

Elevate the pole for the latitude of the given place, screw the quadrant of altitude on the brass meridian over the degree of latitude, move the lower end till its

graduated edge comes to the east point of the horizon, and keep the quadrant in this position; bring the sun's place in the ecliptic for the given day to the brass meridian, set the index of the hour circle to 12, and turn the globe on its axis till the sun's place comes to the graduated edge of the quadrant; the number of hours passed over by the index, will be the time from noon when the sun will be due east, and at the same time past noon he will be due west.

EXAMPLES.

1. At what hour will the sun be due east at Washington, on the 10th of May? And at what hour will he be due west on the same day?

Ans. The time from noon, when the sun is due east, is 4 hours 20 minutes; hence the sun is due east at 40 minutes past 7 in the morning, and due west at 20 minutes past 4 in the afternoon.

2. At what hours will the sun be due east and west at London, on the 21st of June?

3. At what hours will the sun be due east and west at New York, on the 20th of March, and on the 23d of September?

4. Find at what hour the sun is due west at Baltimore, on the 27th of October; and also, how many degrees he is then below the horizon.*

*If the length of the night at the given place exceed the length of the day, the sun will be due east and west, when he is below the horizon.

PROBLEM L.

To find the sun's right ascension, oblique ascension, oblique descension, ascensional or descensional difference, and the time of rising and setting at any place on any day.

RULE.

1. *For the right ascension.* Bring the sun's place in the ecliptic for the given day to the brass meridian, then the degree on the equator cut by the brass meridian, reckoning from the point Aries eastward, will be the right ascension.

2. *For the oblique ascension and descension.* Elevate the pole for the latitude of the given place, bring the sun's place in the ecliptic to the eastern edge of the horizon, and the degree on the equator cut by the horizon, reckoning from the point Aries eastward, will be the oblique ascension. Bring the sun's place in the ecliptic to the western edge of the horizon, and the degree on the equator cut by the horizon, reckoning from the point Aries eastward, will be the oblique descension.

3. *For the ascensional or descensional difference.* Find the difference between the right and oblique ascension; or,* between the right and oblique descension, and this difference turn into time;† then, if the sun's declination and latitude of the place be of the same name, this time shows how long the sun rises before 6, and sets after 6; but, if the declination and latitude be of contrary names, this time shows how long the sun rises after 6, and sets before 6.

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*The difference between the right and oblique ascension is always equal to the difference between the right and oblique descension.

† See Problem XVI.

EXAMPLES.

1. Required the sun's right ascension, oblique ascension, oblique descension, ascensional or descensional difference, and the time of his rising and setting at Philadelphia, on the 25th of May.

Ans. The right ascension is 62 degrees, the oblique ascension is 43° 15′, the oblique descension is 80° 45′, the ascensional difference is (62° 00′ — 43° 15′ =) 18° 45′, or the descensional difference is (80° 45′ — 62° 00′ =) 18° 45′, the same as the ascensional difference; this difference turned into time gives 1 hour 15 minutes; consequently, the sun rises 1 hour 15 minutes before 6, or at 45 minutes past 4; and sets 1 hour 15 minutes after 6, or at 15 minutes past 7.

2. What are the sun's right ascension, oblique ascension, oblique descension, ascensional or descensional difference, and the time of his rising, and setting at Washington, on the 7th of January?

3. Find the sun's right ascension, oblique ascension, ascensional difference, and the time of his rising and setting at Paris, on the 21st of June.

4. What are the sun's right ascension, declination, oblique ascension, oblique descension, ascensional or descensional difference, rising amplitude, setting amplitude, and the time of his rising and setting at New York, on the 21st of December?

PROBLEM LI.

*To find that part of the equation of time, or the difference between the time shown by a well regulated clock and a true sun-dial, which depends upon the obliquity of the ecliptic.**

RULE.

Bring the sun's place in the ecliptic to the brass meridian, then count the number of degrees from Aries to the brass meridian, on the equator and on the ecliptic; the difference reduce to time, counting four minutes of time to a degree, will be the equation of time. If the number of degrees on the equator exceed those on the ecliptic, the sun is slower than the clock; but, if the number of degrees on the ecliptic exceed those on the equator, the sun is faster than the clock.

EXAMPLES.

1. What is the equation of time which depends upon the obliquity of the ecliptic on the 30th of April?

Ans. The degrees on the ecliptic exceed the degrees on the equator by 2½; hence, the sun is 10 minutes faster than the clock.

2. Required the equation of time on the 31st of July.

3. What is the equation of time dependent on the obliquity of the ecliptic on the 14th of January?

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*The true equation of time, or the difference between the time shown by a well regulated clock, and a true sun-dial, cannot be determined by the globe; because it depends upon two causes, viz. the obliquity of the ecliptic, and the irregular motion of the earth in its orbit; and hence, this difference of time can only be found by the globe, so far as it depends upon the obliquity of the ecliptic.

4. On what four days of the year is the equation of time nothing?

PROBLEM LII.

The day and hour being given when a lunar eclipse will happen, to find where it will be visible.

RULE.

Find the place on the globe to which the sun is then verticle, (by Prob. XXII) bring this place to the brass meridian, and observe its latitude; keep the globe from revolving on its axis, and if the latitude be north, elevate the south pole so many degrees above the horizon as are equal to that latitude; but, if it be south, elevate the north pole in a similar manner; set the index of the hour circle to 12; turn the globe on its axis till the index has passed over 12 hours, or till it points to the other 12; then to all places above the horizon the eclipse will be visible; to that place which is antipodes of the place where the sun is vertical, the moon will be vertically eclipsed; to all places along the western edge of the horizon, she will rise eclipsed; and to all places along the eastern edge of the horizon, she will set eclipsed.

EXAMPLES.

1. On the 6th of February, 1822, at 22 minutes past 12 in the morning at Baltimore, there was an eclipse of the moon; where was it visible?

Ans. It was visible to the whole of America, Europe, and a part of Africa.

2. On the 2d of August, 1822, at 16 minutes past 7 in the afternoon at Baltimore, there was an eclipse of the moon; where was it visible?

Note. For more examples, the learner may consult the Almanac for any year.

PROBLEM LIII.

The day and hour being given when a solar eclipse will happen, to find where it will be visible.

RULE.

Find the place on the globe to which the sun is then vertical, (by Prob. XXII.) bring this place to the brass meridian, and elevate the pole for its latitude; then at most of the places above the horizon, the eclipse may be visible.*

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*If the moon change in the node, her shadow or penumbra falls perpendicularly upon the earth in the form of a circle; and the place on the earth where the sun is vertical, is the centre of the penumbral shadow at the middle of the general eclipse. When the moon's diameter appears the largest and the sun's the least, the penumbral shadow may cover a circular space on the earth of 4,900 miles, or 70 degrees diameter. (See Ferguson's Astronomy, Art. 334.)

When the moon changes short of her decending node, the penumbral shadow passes over the northern parts of the earth; and when she changes past the same node, the penumbral shadow passes over the southern parts of the earth; but when she changes short of the ascending node, the penumbral shadow passes over the southern parts of the earth; and when she changes past the same node, the penumbral shadow passes over the northern parts of the earth. The farther the moon changes from either node, within 17 degrees of it, the less proportion of the penumbral shadow falls upon the earth.

And, because the moon may change as well in one node as in another, and at different distances from them, it follows that the variety of eclipses are almost innumerable; hence, if the extent of the penumbral shadow be not accurately found by calculation, it is utterly impossible to find by the globe where a solar eclipse will be visible.

EXAMPLES.

1. On the 21st of February, 1822, at 50 minutes past three o'clock in the afternoon at Baltimore, there was an eclipse of the sun; where might it be visible?

Ans. At Baltimore, &c.

2. On the 27th of August, 1821, at 13¼ minutes past three o'clock in the afternoon at London, there was an eclipse of the sun; where might it be visible, supposing the moon's penumbral shadow to cover a circular space on the earth of 0 degrees diameter?

Note. The learner may consult the Almanacs for more examples.

PROBLEM LIV.

To explain the Phenomenon of the Harvest Moon.

1. In north latitude, the harvest moon is the full moon which rises nearly at the same time for several evenings together, about the time of the autumnal equinox. To explain this phenomenon of the moon's rising, it is necessary to make the following remarks.

The moon's motion is nearly in the ecliptic,* and the different signs of which, on account of its obliquity to the earth's axis, make very different angles with the horizon as they rise and set, especially in considerable latitudes. Those signs which rise with the smallest angles set with the greatest angles, and *vice versa;* and, whenever these angles are least, equal portions of the ecliptic will rise in less time, than when these angles are greater; and the contrary.

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*The moon's orbit is inclined to the ecliptic in an angle of 5° 9′. This obliquity of the moon's orbit to the eclipic, need not be regarded in a general illustration of the problem.

In northern latitudes, the smallest angles are made when Aries and Pisces rise and the greatest when Libra and Virgo rise; consequently when the moon is in Pisces or Aries, she rises with the least difference of time, and she is in these signs twelve times in a year; and when she is in Virgo or Libra, she rises with the greatest difference of time. This peculiar rising of the moon, passes unobserved at all seasons of the year, except in the months of September and October; because in winter, when the moon is in Pisces or Aries, she rises at noon, being then in her first quarter; but when the sun is above the horizon, the moon's rising is never perceived. In spring, the moon rises with the sun in these signs, and changes in them at that time of the year; consequently, she is quite invisible. In summer, when the moon is in these signs, she rises about midnight, being then in her third quarter, and rising so late that she passes unobserved. In autumn, when the moon is in these signs, she rises at or about sun-set, being then full, because, the sun is diametrically opposite to her in Virgo or Libra, answering to the month of September or October, at which time this phenomenon of the moon's rising is very conspicuous, which had passed unobserved at all other times of the year before.

2. In south latitude, the harvest moon is the full moon which rises nearly at the same time for several evenings together, about the time of the vernal equinox. For to the inhabitants of south latitude, the smallest angles are made when Virgo and Libra rise, and the greatest when Pisces and Aries rise; so that, when the moon is in Virgo or Libra, she rises with the least difference of time; and, when she is in Pisces or Aries, she rises with the greatest difference of time; but, when the moon is full in Virgo or Libra, the sun is in Pisces or Aries, which is about the time of the vernal equinox. Hence, the harvest moons are as regular in south latitude as in north latitude, but they take place at opposite times of the year.

RULE.

1. *For north latitude.* Elevate the pole for the latitude of the given place, make a mark on every 12* degrees of the ecliptic with a pencil; preceding and following the point Aries, till there are seven or eight marks, bring that mark which is the nearest to Pisces to the eastern edge of the horizon, and set the index of the hour circle to 12; turn the globe westward on its axis till the other marks successively come to the horizon; the time passed over by the index, between the coming of any mark to the horizon, and that following, will show the difference of time between the moon's rising on any two nights, when she is in or near those marks. If the same marks be brought to the western edge of the horizon, and you proceed in a similar manner, the difference between the time of the moon's setting may be seen; for when the difference between the time of her rising is the least, the difference between the time of her setting will be the greatest; and the contrary.

2. *For south latitude.* Elevate the pole for the latitude of the place, make a mark on every 12 degrees of the ecliptic with a pencil, preceding and following the point Libra, till there are seven or eight marks; bring that mark which is the nearest to Virgo to the eastern edge of the horizon, and set the index of the hour circle to 12; then, proceed precisely as in the above rule,

*The moon moves at the mean rate of 13⅓ degrees in the ecliptic every 24 hours, and the sun advances almost a degree the same way in the same time, caused by the annual motion of the earth; hence, the moon gains but little more than 12 degrees of the sun in the ecliptic every day.

and you will find the difference between the time of the harvest moon's rising, which happens about the time of the vernal equinox.

PROBLEM LV.

To place the terrestrial globe in the sun-shine, so that it may represent the natural position of the earth.

RULE.

Place the globe directly north and south by the mariner's compass, taking care to make a proper allowance for the variation; let the wooden horizon be perfectly horizontal; bring the place in which you are situated to the brass meridian, and elevate the pole for its latitude; then the globe will correspond in every respect with the situation of the earth itself. The poles of the globe will be directed towards the poles in the heavens, the meridians, parallels of latitude, tropics, and all the circles on the globe, will correspond with the same imaginary circles in the heavens; and each kingdom, country, and state, will be directed towards the real one which it represents.

While the sun shines on the globe, one hemisphere will be enlightened, and the other will be in the shade; and hence, at one view may be seen all those places which have day, and those which have night, &c.

PROBLEM LVI.

To find the hour of the day at any place, by placing the globe in the sun-shine.

RULE.

Place the globe due north and south upon a horizontal plane, by the mariner's compass, allowing for the variation, and elevate the pole for the latitude of place; bring the sun's place in the ecliptic to the brass meridian, and set the index of the hour circle to 12; stick a needle perpendicularly in the sun's place in the ecliptic, and turn the globe on its axis till the needle casts no shadow; keep the globe in this position, and the number of hours passed over by the index will show the time from noon, hence the hour of the day is easily obtained.

PROBLEM LVII.

To find the sun's altitude, by placing the globe in the sun-shine.

RULE.

Place the globe upon a horizontal plane, stick a needle over the north pole, in the direction of the axis of the globe, and turn the pole towards the sun, so that the shadow of the needle may fall upon the middle of the brass meridian; then, elevate or depress the pole till the needle casts no shadow; the elevation of the pole above the horizon will be the sun's altitude.

PROBLEM LVIII.

To find the sun's declination and his azimuth, by placing the globe in the sun-shine.

RULE.

Place the globe due north and south upon a horizontal plane, by the compass, or by a meridian line,* and elevate the pole for the latitude of the place; then, if the sun shine over the north pole, his declination is as many degrees north as he shines over the pole; if the sun do not shine so far as the north pole, his declination is as many degrees south, as the enlightened part is distant from the pole.

Observe the degree of the sun's declination on the brass meridian, and stick a needle perpendicularly in the globe under that degree; turn the globe on its axis till the needle casts no shadow; keep the globe in this position, and screw the quadrant of altitude over the degree of latitude; bring the graduated edge of the quadrant to concide with the point where the needle is fixed, and the degree on the horizon will show the azimuth.

*A meridian line may be drawn in the following manner. Describe a circle from the centre of a horizontal plane, in which centre fix a straight wire perpendicular to the plane; mark in the morning where the end of the shadow touches the circumference of the circle; in the afternoon mark where the end of the shadow touches the circumference of the same circle; and, divide the arc of the circle contained between these two marks into two equal parts; a line drawn from the point of division to the centre of the plane, will be a true meridian, or north and south line, if this line be intersected by a perpendicular, that perpendicular, will be an east and west line; thus you will have the four cardinal points of the horizon.

PROBLEM LIX.

To make a horizontal dial for any latitude.

RULE.

Elevate the pole for the latitude of the place, and bring the point Aries to the brass meridian, then, as globes in general have meridians drawn through every 15 degrees of longitude, eastward and westward from the point Aries, observe where the meridians intersect the horizon, and count the number of degrees between the brass meridian and each of the points of intersection; the hour arcs will respectively contain these degrees. The dial must be numbered 12 at the brass meridian, thence, 11, 10, 9, 8, 7, 6, 5, &c. towards the west, for morning hours; and 1, 2, 3, 4, 5, 6, 7, &c. towards the east, for evening hours.

It is unnecessary to draw any more hours, than what will answer to the sun's continuance above the horizon on the longest day at the given place. The style or gnomon of the dial must be fixed in the centre of the dial-plate, and elevated as many degrees above the plane of which, as are equal to the latitude of the place. The dial must be placed, so that the hour 12 may be directed towards the north, if the latitude be north, with the upper part of the gnomon parallel to the earth's axis.

Let it be required to make a horizontal dial for the latitude of Philadelphia.

Elevate the north pole 40 degress above the horizon, and bring the point Aries to the brass meridian; then, you will find the degrees on the eastern part of the horizon, between the brass meridian and the meridians on the globe, to be as follows, viz. 9° 46′, 20° 22′, 32° 44′, 48° 4′, 67° 22′, and 90 degrees for the hours 1, 2, 3, 4, 5, and 6 in the afternoon; and on the western part of the

horizon, the hour arcs will contain the same degrees, for the hours 11, 10, 9, 8, 7, and 6 in the morning. It is unnecessary to find the distance farther than 6, because the hour lines continued through the centre of the dial are the hour lines on the opposite parts thereof.

The following table, calculated by spherical trigonometry,* shows not only the hour arcs, but the halves and quarters from 12 to 6.

Hours.	Hour Angles.	Hour Arcs.	Hours.	Hour Angles.	Hour Arcs.
12	0° 0′	0° 0′	3¼	48° 45′	36° 15′
12¼	3 45	2 25	3½	52 30	39 57
12½	7 30	4 50	3¾	56 15	43 53
12¾	11 15	7 17	4	60 0	48 4
1	15 0	9 46	4¼	63 45	52 30
1¼	18 45	12 19	4½	67 30	57 12
1½	22 30	14 55	4¾	71 15	62 10
1¾	26 15	17 35	5	75 0	67 22
2	30 0	20 22	5¼	78 45	72 48
2¼	33 45	23 15	5½	82 30	78 26
2½	37 30	26 15	5¾	86 15	84 11
2¾	41 15	29 25	6	90 0	90 0
3	45 0	32 44			

*While the globe remains in the position described in the rule, it will be seen that a right-angled spherical triangle is formed, the perpendicular of which is the latitude, the base the hour arc, and the vertical angle the hour angle. Hence,

Radius, sine 90 degrees,
Is to the sine of the latitude;
As tangent of the hour angle,
Is to tangent of the hour arc on the horizon.

PROBLEM LX.

To make a vertical dial, facing the south, in north latitude.

RULE.

Elevate the south pole for the complement of the latitude of the given place, and bring the point Aries to the brass meridian; then, as globes in general have meridians drawn through every 15 degrees of longitude from the point Aries, observe where the meridians intersect the horizon, and count the number of degrees between the brass meridian and each of the points of intersection; the hour arcs will respectively contain these degrees. The dial must be numbered 12 at the brass meridian, thence, 11, 10, 9, 8, 7, 6, towards the west for morning hours; and 1, 2, 3, 4, 5, 6, towards the east, for evening hours. It is unnecessary to draw any more hours on such a dial as this than from 6 in the morning to 6 in the evening, because the sun cannot shine longer upon it than 12 hours in the course of one day. The style or gnomon must be parallel to the earth's axis and elevated as many degrees above the plane of the dial-plate, as are equal to the complement of the latitude.

Let it be required to make a vertical dial, facing the south, for the latitude of Philadelphia.

Elevate the south pole 50 degrees above the horizon, and bring the point Aries to the brass meridian; then, you will find the degrees on the eastern part of the horizon, between the south point and the meridians on the globe, to be as follows, viz. 11° 36′, 23° 51′, 37° 27′, 53° 0′, 70° 43′, and 90 degrees, for the hours 1, 2, 3, 4, 5, and 6 in the afternoon; and on the western part of the horizon, the hour arcs will contain the same degrees, for the hours, 11, 10, 9, 8, 7, and 6 in the morning.

The following table contains not only the hour arcs, but the halves and quarters from 12 to 6, it is calculated precisely in the same manner as the table in the preceding problem, only, using the complement of the latitude instead of the latitude.

Hours.	Hour Angles.		Hour Arcs.		Hours.	Hour Angles.		Hour Arcs.	
12	0°	0′	0°	0′	3¼	48°	45′	41°	8′
12¼	3	45	2	52	3½	52	30	44	57
12½	7	30	5	46	3¾	56	15	48	54
12¾	11	15	8	40	4	60	0	53	0
1	15	0	11	36	4¼	63	45	57	14
1¼	18	45	14	35	4½	67	30	61	36
1½	22	30	17	36	4¾	71	15	66	6
1¾	26	15	20	42	5	75	0	70	43
2	30	0	23	51	5¼	78	45	75	27
2¼	33	45	27	6	5½	82	30	80	15
2½	37	30	30	27	5¾	86	15	85	7
2¾	41	15	33	54	6	90	0	90	0
3	45	0	37	27					

It may be here observed that the time shown by a sun-dial is the apparent time, and not the true or mean time of the day, as shown by a well regulated clock. See definitions 50, and 51. The following table of the equation of time will show how much a clock should be faster or slower than a sun-dial.

Days and Months.	Minutes.		Days and Months.	Minutes.		Days and Months.	Minutes.	
Jan. 1	4	Clock faster than the Dial.	19	1	Clock slower.	24	8	Clock slower than the Dial.
3	5		24	2		27	9	
5	6		30	3		30	10	
7	7		May 13	4		Oct. 3	11	
9	8		29	3		6	12	
12	9		June 5	2		10	13	
15	10		10	1		14	14	
18	11		15	0		19	15	
21	12		*			27	16	
25	13		20	1	Clock faster.	Nov. 15	15	
31	14		25	2		20	14	
Feb. 10	15		29	3		24	13	
21	14		July 5	4		27	12	
27	13		11	5		30	11	
March 4	12		28	6		Dec. 2	10	
8	11		Aug. 9	5		5	9	
12	10		15	4		7	8	
15	9		20	3		9	7	
19	8		24	2		11	6	
22	7		28	1		13	5	
25	6		31	0		16	4	
28	5		*			18	3	
April 1	4		Sept. 3	1	Clock slower.	20	2	
4	3		6	2		22	1	
7	2		9	3		24	3	
11	1		12	4		*		
15	0		15	5		26	1	Cl. fa.
			18	6		28	2	
			21	7		30	3	

PROBLEMS

PERFORMED BY

THE CELESTIAL GLOBE.

PROBLEM I.

*To find the latitude and longitude of any star.**

RULE.

Bring the north or south pole of the ecliptic, according as the star is on the north or south side of the ecliptic, to the brass meridian, and screw the quadrant of altitude upon the brass meridian over the pole of the ecliptic; keep the globe from revolving on its axis, and move the quadrant till its graduated edge comes over the given star; then, the degree on the quadrant over the star is its latitude, and the number of degrees on the ecliptic, reckoning from the point Aries eastward to the quadrant, is its longitude.

* The latitudes and longitudes of the moon and planets must be found from the Nautical Almanac, or an Ephemeris; because, they cannot be placed on the globe, as the stars are placed, on account of their continual motion.

EXAMPLES.

1. Required the latitude and longitude of α *Markab*, in Pegasus.

Ans. Latitude 19° 25′ N. and longitude 11 signs 20° 54′.

2. Required the latitudes and longitudes of the following stars.

α, *Altair*, in the Eagle.
β, *Mirach*. in Andromeda.
α, *Arcturus*, in Bootes.
α, *Aldebaran*, in Taurus.
α, *Vega*, in Lyra.
α, *Fomalhaut*, in the S. Fish.
β, *Rigel*, in Orion.
γ, *Bellatrix*, in Orion.
α, *Capella*, in Auriga.
α, *Procyon*, in Canis Minor.
γ, *Rastaben*, in Draco,
β, *Pollux*, in Gemini.

PROBLEM II.

To find the right ascension and declination of any star.

RULE *

Bring the given star to that part of the brass meridian which is numbered from the equinoctial towards the

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*This rule will answer for finding the sun's right ascension and declination, by using the sun's place in the ecliptic instead of the given star. The right ascension and declination of the moon and planets must be found from the Nautical Almanac.

poles; the degree on the brass meridian above the star is the declination, and the degree on the equinoctial cut by the brass meridian, reckoning from the point Aries eastward, is the right ascension.

EXAMPLES.

1. Required the right ascension and declination of *α Arcturus*, in the right thigh of Bootes.

Ans. Right ascension 211° 55′, declination 20° 8′ N.

2. Required the right ascension and declinations of the following stars:

β, *Albireo*, in Cygnus.
γ, *Algorab*, in the Crow.
α, *Deneb*, in Cygnus.
α, *Canopus*, in Argo Navis.
β, *Rigel*, in Orion.
ε, *Vendemiatrix*, in Virgo.
ε, *Mirach*, in Bootes.
α, *Castor*, in Gemini.
β, *Algal*, in Perseus.
α, *Altair*, in the Eagle.
α, *Antares*, in the Scorpion.
α, *Scheder*, in Cassiopeia.

PROBLEM III.

The latitude and longitude of the moon, a star, or a planet being given, to find its place on the globe.

RULE.

Bring the north or south pole of the ecliptic, according as the latitude is north or south, to the brass meridian and screw the quadrant of altitude upon the brass meridian over the pole of the ecliptic; keep the globe from revolving on its axis, and move the quadrant till its graduated edge cuts the given degree of longitude on the ecliptic; then under the given latitude, on the quadrant, you will find the star, or the place of the moon or planet.

EXAMPLES.

1. What star has 2 signs 7° 12′ of longitude, and 5° 28′ S. latitude?

Ans. α Aldebaran, in Taurus.

2. What stars have the following latitudes and longitudes?

LAT.			LON.			LAT.			LON.		
6°	40′	N.	3s	20°	40′	19°	25′	N.	11s	20°	54′
9	58	N.	1	5	5	4	33	S.	8	7	11
21	7	S	11	1	15	29	19	N.	9	29	10

3. On the 10th of July, 1821, at midnight the moon's longitude was 7s 28° 24′, and her latitude 5° 5′ S.; required her place on the globe.

4. On the 1st of July, 1821, the longitudes and latitudes of the planets were as follows; required their places on the globe.

	LON.			LAT.				LON.			LAT.		
☿	4s	5°	4′	0°	31′	N.	♃	0s	26°	27′	1°	15′	S.
♀	3	19	59	1	6	N.	♄	0	25	29	2	26	S.
♂	2	1	59	0	15	S.	♅	9	0	45	0	15	S.

PROBLEM IV.

The right ascension and declination of the moon, a star, or a planet being given, to find its place on the globe.

RULE.

Bring the given degree of right ascension to that part of the brass meridian which is numbered from the equinoctial towards the poles; then, under the given declination on the brass meridian, you will find the star, or the place of the moon or planet.

EXAMPLES.

1. What star has 163° 6′ of right ascension, and 62° 44′ N. declination?

Ans. *α Dubhe*, in the back of the Great Bear.

2. On the 10th of September, 1821, the moon's right ascension was 336° 25′, and her declination 9° 52′ S. find her place on the globe at that time.

Ans. About 4° in Pisces, nearly in the plane of the ecliptic.

3. What stars have the following right ascensions and declinations?

RIGHT ASCEN.		DECLIN.			RIGHT ASCEN.		DECLIN.	
29°	14′	22°	36′	N.	h.	m.		
86	20	7	22	N.	22	47	20° 35′	S.
176	3	54	42	N.	20	35	44 38	N.

4. On the 25th of October, 1821, the declination of Venus was 23° 56′ S. and her right ascension 249° 15′; find her place on the globe at that time.

PROBLEM V.

The month, day, and hour of the day at any place being, given, to place the globe in such a manner as to represent the heavens at that time and place; in order to find the relative situations and names of the constellations and principal stars.

RULE.

Place the globe, on a clear star-light night, due north and south by the compass upon a horizontal plane, where the surrounding horizon is uninterrupted by different objects, and elevate the pole for the latitude of the place; find the sun's place in the ecliptic for the given day, bring it to the brass meridian, and set the index of the hour circle to 12; then, if the time be after noon, turn the globe westward on its axis till the index has passed over as many hours as the time is past noon; but, if the time be before noon, turn the globe eastward till the index has passed over as many hours as the time wants of noon; keep the globe in this position; then the flat end of a pencil being placed on any star on the globe, so as to point towards the centre, the other end will point to that particular star in the heavens.

PROBLEM VI.

The month, day, and hour of the day at a place being given, to find what stars are rising, setting, culminating, &c.

RULE.

Elevate the pole for the latitude of the place, bring the sun's place in the ecliptic to the brass meridian, and set the index of the hour circle to 12; then, if the time be after noon, turn the globe westward on its axis till the index has passed over as many hours as the time is past noon; but, if the time be before noon turn the globe eastward till the index has passed over as many hours as the time wants of noon; keep the globe in this position; then, all the stars along the eastern edge of the horizon will be rising at the given place, those along the western edge will be setting, those under the brass meridian above the horizon will be culminating, those above the horizon will be visible, and those below the horizon will be invisible. If the globe be turned on its axis from east to west, those stars which do not descend below the horizon never set at the given place; and those which do not ascend above the horizon never rise.

EXAMPLES.

1. On the 21st of October, when it is 7 o'clock in the evening at Philadelphia, what stars are rising, what stars are setting, and what stars are culminating?

Ans. Menkar in Cetus is rising; *Capella* a little above the eastern edge of the horizon, *Deneb* on the meridian, *Arcturus* a little east of the western edge of the horizon; *Antares* in the Scorpion, setting, &c.

2. On the 16th of January, when it is 3 o'clock in the morning at Baltimore, what stars are rising, what stars are setting, and what stars are culminating?

Ans. *Deneb* is rising, *Dubhe* culminating; *Alamak* in Andromeda setting, &c.

3. On the 10th of November, when it is 10 o'clock in the evening at Washington, what stars are rising, what stars are setting, and what stars are culminating?

4. What stars never set at Paris, and what stars never rise at the same place?

5. How far northward must a person travel from New-York to lose sight of *Antares*?

6 How far southward must a person travel from Mexico to lose sight of *Dubhe?*

PROBLEM VII.

The month, and day being given, to find at what hour of the day any star, or planet, will rise, culminate, and set at any given place.

RULE.

Elevate the pole for the latitude of the given place, bring the sun's place in the ecliptic for the given day to the brass meridian, and set the index of the hour circle to 12; then, if the star or planet* be below the horizon, turn the globe westward on its axis till the star, &c. comes to the eastern edge of the horizon, the brass meridian and the western edge of the horizon successively; the hours passed over by the index res-

* The planet's place on the globe must be determined by Prob. III. or IV.

pectively will show the time from noon, that the star or planet rises, culminates, and sets.

If the star, &c. be above the horizon and east of the brass meridian, find the time of culminating, setting, and rising, in a similar manner; but, if it be west of the brass meridian, then you will find the time of setting, rising, and culminating.

EXAMPLES.

1. At what time will *Arcturus* rise, culminate, and set at Washington, on the 21st of August?

Ans. It will rise at 45 minutes past 8 o'clock in the morning, culminate at 4 in the afternoon, and set at 15 minutes past 11 o'clock at night.

2. On the 25th of August, 1821, the longitude of Venus was 5 signs 27° 22', and her latitude 1° 4' N. at what time did she rise, culminate and set, at Baltimore, and was she a morning or evening star?

Ans. Venus culminated at 20 minutes before 2 o'clock in the afternoon, set at 15 minutes before 8, and rose at 25 minutes before 8. Venus was an evening star, because she set shortly after the sun.

3. At what time will *Sirius* rise, culminate, and set at New-York, on the 25th of December?

4. On the 1st of October, 1821, the right ascension of Jupiter was 26 degrees, and his declination 9° 6' N. at what time did he rise, culminate and set, at Washington, and was he a morning or an evening star?

PROBLEM VIII.

The month, and day being given, to find all those stars that rise and set acronycally, cosmically, and heliacally at any given place.

RULE.

Elevate the pole for the latitude of the given place. Then,

1. *For the acronycal rising and setting.* Bring the sun's place in the eliptic to the western edge of the horizon, and all the stars along the eastern edge of the horizon will rise acronycally, while those along the western edge will set acronycally.

2. *For the cosmical rising and setting.* Bring the sun's place to the eastern edge of the horizon; and all the stars along that edge of the horizon will rise cosmically, while those along the western edge will set cosmically.

3. *For the heliacal rising and setting.* Screw the quadrant of altitude on the brass meridian over the degree of latitude, turn the globe eastward on its axis till the sun's place cuts the quadrant 12 degrees* below the eastern edge of the horizon; then, all stars of the first magnitude, along the same edge of the horizon, will rise heliacally; continue the motion of the globe till

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* The brighter a star is when above the horizon, the less will the sun be depressed below the horizon, when that star first becomes visible; hence, the heliacal rising and setting of the stars will vary according to their different degrees of magnitude and brilliancy. According to Ptolemy, stars of the first magnitude are seen rising and setting when the sun is 12 degrees below the horizon, stars of the second magnitude when the sun is 13 degrees below the horizon, stars of the third magnitude 14 degrees, and so on, reckoning one degree for each magnitude.

the sun's place intersects the quadrant in 13, 14, 15, &c. degrees below the horizon, and you will find the stars of the second, third, fourth, &c. magnitudes, which rise heliacally, at the given place on the given day. Bring the quadrant to the western edge of the horizon, turn the globe westward on its axis, till the sun's place intersects the quadrant in a similar manner as before, and you will find all the stars that set heliacally.

EXAMPLES.

1. What stars rise and set acronycally at Washington, on the 1st of January?

Ans. *Castor* in Gemini *Betelguese* in Orion, &c. rise acronycally; and δ in Bootes, γ in Hercules, &c. set acronycally.

2. What stars rise and set cosmically at Philadelphia, on the 2d of June?

Ans. *Aldebaran*, and β in Taurus, &c. rise cosmically, and *Arcturus*, &c. in Bootes, set cosmically.

3. What star of the first magnitude rises heliacally at New-York, on the 25th of June?

Ans. *Aldebaran*, in Taurus.

4. What star of the first magnitude sets heliacally at Baltimore, on the 22d of January?

Ans. *Altair*, in the Eagle.

5. What stars rise and set cosmically at Dublin, on the 14th of November?

6. What stars rise and set acronycally at London on the 27th of April?

PROBLEM IX.

To find the time of the year at which any given star rises or sets acronycally, at a given place.

RULE.

Elevate the pole for the latitude of the given place, bring the given star to the eastern edge of the horizon, observe what degree of the ecliptic is cut by the western edge of the horizon; and, the day of the month answering to that degree will show the time when the star rises acronycally, or when it begins to be visible in the evening. Bring the given star to the western edge of the horizon, observe what degree of the ecliptic is cut by the same edge of the horizon; and the day of the month answering to that degree will show the time when the star sets acronycally, or when it ceases to appear in the evening.

EXAMPLES.

1. At what time does *Deneb* rise acronycally at Baltimore, and on what day of the year does it set acronycally?

Ans. Deneb rises acronycally on the 21st of May, and it sets acronycally on the 22d of March.

2. On what day of the year does *Arcturus* rise acronycally at Washington, and at what time does it set acronycally?

3. On what day of the year does *Aldebaran* begin to be visible in the evening at Glasgow, and on what day does it cease to appear in the evening?

4. At what time does *Procyon* in Canis Minor rise acronycally at New-York, and on what day of the year does it set acronycally?

PROBLEM X.

To find the time of the year at which any given star rises or sets cosmically, at a given place.

RULE.

Elevate the pole for the latitude of the given place, bring the given star to the eastern edge of the horizon, and observe what degree of the ecliptic is cut by the same edge of the horizon; the month and day of the month answering to that degree, will show the time when the star rises cosmically, or when it rises with the sun. Bring the given star to the western edge of the horizon, and observe what degree of the ecliptic is cut by the eastern edge; the month and day of the month answering to that degree, will show the time when the star sets cosmically, or when it sets at sun-rising.

EXAMPLES.

1. At what time of the year does *Procyon* in Canis Minor, rise cosmically at Washington; and, at what time does the same star set cosmically at the same place?

Ans. Procyon rises cosmically on the 24th of July, or rises with the sun on that day, and sets cosmically on the 25th of December, or sets at sun-rising on that day.

2. At what time of the year does *Regulus* rise cosmically at New-York, and at what time does it set cosmically?

3. At what time of the year does *Bellatrix* in Orion rise with the sun at London, and at what time does it set at sun-rising?

4. At what time of the year does *Arcturus* rise with the sun at Philadelphia; and at what time of the year will it set, when the sun rises at the same place?

PROBLEM XI.

To find the time of the year at which any given star rises or sets heliacally, at a given place.

RULE.

Elevate the pole for the latitude of the given place, and screw the quadrant of altitude on the brass meridian over the degree of latitude; bring the given star to the eastern edge of the horizon, and move the quadrant till it cuts the ecliptic 12* degrees below the eastern edge of the horizon, if the star be of the first magnitude, 13 degrees if it be of the second magnitude; 14 degrees if it be of the third magnitude, and so on: the degrees of the ecliptic cut by the quadrant will show, on the horizon, the day of the month, when the star rises heliacally. Bring the given star to the western edge of the horizon, and move the quadrant of altitude till it cuts the ecliptic below the western edge of the horizon, in a similar manner as before; the degree of the ecliptic cut by the quadrant will show, on the horizon, when the star sets heliacally.

EXAMPLES.

1. At what time of the year does *Arcturus* rise heliacally at Jerusalem, and at what time does it set heliacally at the same place?

Ans. *Arcturus* will rise heliacally on the 23d of October, that is, when it first becomes visible in the morning, after having been so near the sun as to be hid by

*See the note to Prob. VIII.

the splendour of his rays; and, *Arcturus* will set heliacally on the 7th of November, that is, when it first becomes invisible in the evening, on account of its nearness to the sun.

2. At what time of the year does *Sirius*, or the Dog Star, rise heliacally at Rome, and at what time does it set heliacally at the same place?

3. What time of the year does *Procyon* rise heliacally at New-York, and at what time does it set heliacally at the same place?

4. At what time of the year does *Spica* rise heliacally at London, and at what time does it set heliacally at the same place?

PROBLEM XII.

To find the diurnal arc of any star, or its continuance above the horizon for any day at a given place.

RULE.

Elevate the pole for the latitude of the given place, bring the given star to the eastern edge of the horizon, and set the index of the hour circle to 12; turn the globe westward on its axis till the given star comes to the western edge of the horizon; the hours passed over by the index will be the star's diurnal arc, or its continuance above the horizon for any day, at the given place.

EXAMPLES.

1. What is the diurnal arc of *Regulus*, or its continuance above the horizon for one day at New-York?

Ans. 13 hours 35 minutes.

2. What is the diurnal arc of *Sirius*, at London?

3. *Aldebaran* in Taurus rises cosmically at Philadelphia on the 2d of June, does that star set before or after the sun on the same day, and how long?

4. What is the diurnal arc of *Arcturus* at Washington?

5. How long does *Procyon* continue above the horizon, during one revolution of the earth on its axis, at Baltimore?

6. What is the diurnal arc of *Capella* at Rome?

PROBLEM XIII.

To find the oblique ascension and descension of any star, and its rising and setting amplitude, at a given place.

RULE.

Elevate the pole for the latitude of the given place, and bring the given star to the eastern edge of the horizon, then the degree of the equinoctial cut by the same edge of the horizon, will be the oblique ascension, and the number of degrees between the star and the eastern point of the horizon will be its rising amplitude: turn* the globe westward on its axis till the given star comes to the western edge of the horizon, then the degree of the equinoctial cut by the same edge of the horizon, will be the oblique descension, and the number of degrees between the star and the western point of the horizon will be its setting amplitude.

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*The star's diurnal arc may here be found, by observing the number of hours passed over by the index, during this motion of the globe on its axis.

EXAMALES.

1. Required the oblique ascension and descension of *Castor*, and its rising and setting amplitude, at Philadelphia.

Ans. The oblique ascension is 78 degrees, oblique descension 144 degrees; rising amplitude 45 degrees to the north of the east, and setting amplitude 45 degrees to the north of the west.

2. Required the oblique ascension and descension of *Regulus*, and its rising and setting amplitude, at New York.

3. Required the oblique ascension, oblique descension, and rising and setting amplitude of γ in Leo, at Washington.

4. Required the rising and setting amplitude of *Arcturus*, its oblique ascension, and oblique descension, at London.

PROBLEM XIV.

To find the distance in degrees between any two stars, or the angle which they subtend, as seen by a spectator on the earth.

RULE.

Lay the graduated edge of the quadrant of altitude over the two given stars, so that the division marked 0 may be on one of the stars; the degrees on the quadrant comprehended between the two stars will be their distance, or the angle which they subtend, as seen by a spectator on the earth.

EXAMPLES.

1. What is the distance between *Arcturus* and *Dubhe?*

Ans. 54 degrees.

2. What is the distance between α in Serpentarius, and γ in Cygnus?

3. What is the distance between *Lyra* and *Mirach?*

4. What is the distance between *Gemma* and *Antares?*

5. What is the distance between *Aloith* in the tail of the Great Bear, and β in the tail of Leo?

6. What is the distance between *Deneb* and *Menrar?*

PROBLEM XV.

To find the meridian altitude of any star or planet, on any day, at a given place.*

RULE.

Elevate the pole for the latitude of the given place, and bring the given star or planet's† place on the globe to the brass meridian; then the number of degrees on the meridian, contained between the star or planet's place and the horizon, will be the altitude required.

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*It is not requisite to give the day of the month, in finding the meridian altitude of the stars, because it is invariable at the same place.

† The moon or planet's place on the globe must be determined by Prob. III. or IV.

EXAMPLES.

1. What is the meridian altitude of *Aldebaran* in Taurus, at Washington?

Ans. 67° 15′.

2. What is the meridian altitude of *Arcturus* at Paris?

3. What is the meridian altitude of *Capella* at Baltimore?

4. On the 25th of October, 1821, the longitude of Mars was 4 signs 14° 50′, and latitude 1° 30′ north; what was his meridian altitude at New York?

5. On the 8th of November, 1821, at the time of the moon's passage over the meridian of Greenwich, her right ascension was 31° 14′,* and declination 17° 27′ N.; required her meridian altitude at Greenwich.

6. On the 1st of November, 1821, the right ascension of Venus was 17 hours 13 minutes, and declination 25° 8′ south; required her meridian altitude at Baltimore.

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* The moon's right ascension and declination at the time of her passage over the meridian may be found thus.

On the 8th of November, 1821, by the Nautical Almanac.

Moon's right ascension at midnight was	31°	45′	decl.	17°	40′N.
do. at noon	24	26		14	40 N.
Increase in 12 hours from noon	7	19		3	00

Then, as 12h. : 7° 19′ : : 11h. 10m. the time of the moon's passage over the meridian : 6° 48′; hence, 24° 26′ + 6° 48′ = 31° 14′, the moon's right ascension at 10 minutes past 11. And as 12h. : 3° 00′ : : 11h. 10m. : 2° 47′; hence, 14° 40′ + 2° 47′ = 17° 27′, the moon's declination at 10 minutes past 11.

PROBLEM XVI.

The month, day, and hour of the day at any place being given, to find the altitude of any star, and its azimuth.

RULE.

Elevate the pole for the latitude of the given place, and screw the quadrant of altitude on the brass meridian over the degree of latitude; bring the sun's place in the ecliptic for the given day to the brass meridian, and set the index of the hour circle to 12; then, if the given time be before noon, turn the globe eastward on its axis, till the index has passed over as many hours as the time wants of noon; but, if the given time be past noon, turn the globe westward on its axis till the index has passed over as many hours as the time is past noon; keep the globe from revolving on its axis, and move the quadrant of altitude, till its graduated edge comes over the given star; the degrees on the quadrant, comprehended between the horizon and the star, will be the altitude; and the degrees on the horizon, between the north or south point thereof and the quadrant, wlil be the azimuth.

EXAMPLES.

1. Required the altitude and azimuth of β in Leo at Philadelphia, on the 20th of March, at 10 o'clock in the evening.

Ans. The altitude is 59 degrees and azimuth 49½ degrees from the south towards the east.

2. On what point of the compass does *Altair* bear at Washington, on the 19th of April, at 3 o'clock in the morning; and what is its altitude?

3. Required the altitude and azimuth of *Arcturus* at Dublin, on the 5th of September, at 8 o'clock in the evening.

4. Required the altitude and azimuth of *Markab* in Pegasus, at Paris, on the 30th of August, at 9 o'clock in the evening.

PROBLEM XVII.

The month and day of the month being given, and the altitude of a star at any place, to find the hour of the night, and the star's azimuth.*

RULE.

Elevate the pole for the latitude of the given place, and screw the quadrant of altitude on the brass meridian over the degree of latitude, bring the sun's place in the ecliptic for the given day to the brass meridian, and set the index of the hour circle to 12; bring the quadrant to that side of the meridian† on which the star was situated when observed; turn the globe westward on its axis, till the centre of the star cuts the given altitude on the quadrant; then the hours passed over by the index will show the time from noon, when the star has the given altitude, and the degree on the horizon intersected by the quadrant, will be the azimuth.

* If the observation be made in the morning, the hour can be as easily found by turning the globe eastward on its axis, and the number of hours passed over by the index will show the time from noon, in the morning, when the star has the given altitude.

† A star will have the same altitude on both sides of the meridian; therefore, it is necessary to mention on which side of the meridian the star was situated at the time of observation.

EXAMPLES.

1. At Philadelphia, on the 20th of March, the star β in Leo, was observed to be 59 degrees above the horizon, and east of the meridian, what hour was it, and what was the star's azimuth?

Ans. It was 10 o'clock in the evening, and the star's azimuth, was 49½ degrees from the south towards the east.

2. At Washington, on the 23d of October, the star *Lyra* was observed to be 52 degrees above the horizon, and west of the meridian, what hour was it, and what was the star's azimuth?

3. At Dublin, on the 11th of December, *Mirach* in Andromeda was observed to be 65 degrees above the horizon, and east of the meridian, what hour was it, and what was the star's azimuth?

4. At Baltimore, on the 1st of January in the morning, the altitude of *Arcturus* was observed to be 44½ degrees, and it was east of the meridian, what hour was it, and what was the star's azimuth?

PROBLEM XVIII.

The month and day of the month being given, and the azimuth of a star at any place, to find the hour of the night, and the star's altitude.

RULE.

Elevate the pole for the latitude of the given place, and screw the quadrant of altitude on the brass meridian over the degree of latitude; bring the sun's place in the ecliptic for the given day to the brass meridian, and set the index of the hour circle to 12; bring the graduated edge of the quadrant to coincide with the

given azimuth on the horizon, and keep it in that position; then, turn the globe westward on its axis till the centre of the given star comes to the graduated edge of the quadrant, the hours passed over by the index will show the time from noon when the star has the given azimuth, and the degrees on the quadrant, comprehended between the horizon and the star, will be the altitude.

EXAMPLES.

1. At Philadelphia on the 20th of March, the azimuth of β in Leo was observed to be 49¼ degrees from the south towards the east, what hour was it, and what was the star's altitude?

Ans. It was 10 o'clock in the evening, and the star's altitude was 59 degrees.

2. At Washington on the 23d of October, the azimuth of *Lyra* was 73 degrees from the north towards the west, what hour was it, and what was the star's altitude?

3. At Dublin on the 5th of September, the azimuth of *Arcturus* was 89 degrees from the south towards the west, what hour was it, and what was the star's altitude?

4. At Paris on the 30th of August, the azimuth of *Markab* in Pegasus was 68 degrees from the south towards the east, what hour was it, and what was the star's altitude?

PROBLEM XIX.

The month and day of the month being given, and the hour when any known star rises or sets, to find the latitude of the place.

RULE.

Bring the sun's place in the ecliptic for the given day to the brass meridian, and set the index of the hour circle to 12; then, if the given time be before noon, turn the globe eastward on its axis as many hours as the time wants of noon; but, if the given time be past noon, turn the globe westward on its axis as many hours as the time is past noon; keep the globe from revolving on its axis, elevate or depress the pole till the centre of the given star coincides with the edge of the horizon, and the elevation of the pole will show the latitude required.

EXAMPLES.

1. In what latitude does *Menkar* in Cetus rise at 7 o'clock in the evening of the 21st of October?

Ans. 40 degrees north.

2. In what latitude does *Arcturus* rise at 45 minutes past 8 o'clock in the morning, on the 21st of August?

3. In what latitude does *Alamak*, in Andromeda, set at 3 o'clock in the morning, on the 16th of January?

4. In what latitude does *Alphacca*, in the northern Crown, rise at 9 o'clock in the evening, on the 9th of February?

PROBLEM XX.

The meridian altitude of a known star being given, to find the latitude of the place of observation.

RULE.

Bring the centre of the given star to that part of the brass meridian which is numbered from the equinoctial towards the poles; count as many degrees on the brass meridian, from the star, either towards the north or south point of the horizon, according as the star was north or south of you when observed, as are equal to the given altitude, and mark where the reckoning ends; then, elevate or depress the pole till this mark coincides with the north or south point of the horizon, and the elevation of the pole will show the latitude.

EXAMPLES.

1. In what latitude is the meridian altitude of *Aldebaran* in Taurus, $67\frac{1}{4}$ degrees above the south point of the horizon?

Ans. 38° 53′ north.

2. In what latitude is the meridian altitude of *Arcturus*, $61\frac{1}{2}$ degrees above the south point of the horizon?

3. Being at sea on the 22d of August 1821, I took the meridian altitude of *Altair*, and found it to be $56\frac{1}{4}$ degrees above the south point of the horizon; required the latitude of the ship.

4. In what latitude is the meridian altitude of *Lyra* 80 degrees above the north point of the horizon?

PROBLEM XXI.

The altitude of two known stars being given, to find the latitude of the place.

RULE.

Take the complement of the altitude of the first given star from the equinoctial in a pair of compasses, and, with one foot in the centre of that star, and a fine pencil in the other foot, describe an arc; take the complement of the altitude of the second star from the equinoctial as before, and, with one foot in the centre of this star, describe an arc to cross the former arc; bring the point of intersection to that part of the brass meridian which is numbered from the equinoctial towards the poles, and the degree above it will be the latitude sought.

EXAMPLES.

1. In north latitude, I observed the altitude of *Capella* to be 30 degrees, and that of *Castor* 40 degrees; what latitude was I in?

Ans. 40 degrees north.

2. At sea in north latitude, I observed the altitude of *Lyra* to be 35 degrees, and that of *Altair* 25 degrees; required the latitude in.

3. In north latitude, I observed the altitude of *Mencar* in Cetus to be 60 degrees, and that of *Algenib* in Pegasus 35 degrees; what was the latitude of the place of observation?

4. In north latitude, the altitude of *Procyon* was observed to be 40 degrees, and that of *Bellatrix* in Orion, at the same time, was 64 degrees, required the latitude of the place of observation.

PROBLEM XXII.

Two stars being given, the one on the meridian and the other on the east or west point of the horizon, to find the latitude of the place.

RULE.

Bring the star which was observed to be on the meridian, to the brass meridian; keep the globe from revolving on its axis, and elevate or depress the pole till the entre of the other given star coincides with the eastern or western edge of the horizon; then the elevation of the pole will show the latitude.

EXAMPLES.

1. When *Lyra* was on the meridian, β in Leo was setting; required the latitude.

Ans. 35 degrees north.

2. When *Markab* in Pegasus was on the meridian *Castor* was rising; required the latitude.

3. When *Arcturus* was on the meridian, *Procyon* was setting; required the latitude.

4. In what latitude is β in Leo rising, when *Aldebaran* is on the meridian?

PROBLEM XXIII.

The latitude of a place, the day of the month, and two stars that have the same azimuth, being given, to find the hour of the night, and the common azimuth.

RULE.

Elevate the pole for the latitude of the place, and screw the quadrant of altitude on the brass meridian over that latitude; bring the sun's place in the ecliptic for the given day to the brass meridian, and set the index of the hour circle to 12; turn the globe westward on its axis, till the two given stars coincide with the graduated edge of the quadrant of altitude; the hours passed over by the index will show the time from noon, and the degree of the horizon, intersected by the quadrant, will show the common azimuth.

EXAMPLES.

1. At what hour at Philadelphia, on the 10th of May, will *Arcturus*, and β in Libra, have the same azimuth, and what will that azimuth be?

Ans. At 10 o'clock in the evening, and the azimuth will be 36 degrees from the south towards the east.

2. At what hour at Paris, on the 16th of August, will *Lyra* and *Altair* have the same azimuth, and what will that azimuth be?

3. On the 7th of September, what is the hour at Washington, when *Deneb* in Cygnus, and *Gemma* have the same azimuth, and what is the azimuth?

4. On the 19th of May, what is the hour at London, when *Dubhe* and *Capella* have the same azimuth, and what is the azimuth?

PROBLEM XXIV.

The latitude of a place, the day of the month, and two stars that have the same altitude, being given, to find the hour of the night.

RULE.

Elevate the pole for the latitude of the place, and screw the quadrant of altitude on the brass meridian over that latitude; bring the sun's place in the ecliptic for the given day to the brass meridian, and set the index of the hour circle to 12; turn the globe westward on its axis till the two given stars coincide with the given altitude on the graduated edge of the quadrant; the hours passed over by the index will show the time from noon when the two stars have that altitude.

EXAMPLES.

1. At what hour at New-York, on the 22d of August, will *Dubhe* and *Arcturus* have each 24 degrees of altitude?

Ans. At 9 o'clock in the evening.

2. At what hour at Washington, on the 17th of February, will *Aldebaran* in Taurus, and *Betelguex* in Orion, have each 59½ degrees of altitude?

3. At what hour at Dublin, on the 22d of December, will *Procyon* and *Alioth* have each 28 degrees of altitude?

4. At what hour at London, on the 16th of November, will *Algenib* in Pegasus, and *Algol* in Perseus, have each 53 degrees of altitude?

PROBLEM XXV.

To find on what day of the year, any given star passes the meridian of any place, at any given hour.

RULE.

Bring the given star to the brass meridian, and set the index of the hour circle to 12; then, if the given time be before noon, turn the globe westward on its axis, till the index has passed over as many hours as the time wants of noon; but, if the given time be past noon, turn the globe eastward on its axis, till the index has passed over as many hours as the time is past noon; then, the degree of the ecliptic cut by the brass meridian, will show on the horizon the day of the month required.

EXAMPLES,

1. On what day of the month does *Arcturus* come to the meridian of Philadelphia, at 9 o'clock in the evening.

Ans. On the 7th of June.

2. On what day of the month, and in what month, does *Altair* come to the meridian of Washington, at 3 o'clock in the morning?

3. On what day of the month, and in what month does *Sirius* come to the meridian of Baltimore, at midnight?

4. On what day of the month, and in what month, does *Procyon* come to the meridian of Greenwich, at noon?*

*When the given star comes to the meridian at noon, the sun's place will be found under the brass meridian, without turning the globe.

PROBLEM XXVI.

The day of the month and hour of the night or morning at any place being given, to find what planets will be visible at that hour.

RULE.

Elevate the pole for the latitude of the place, bring the sun's place in the ecliptic for the given day to the brass meridian, and set the index of the hour circle to 12; then, if the given time be before noon, turn the globe eastward on its axis till the index has prssed over as many hours as the time wants of noon; but, if the given time be past noon, turn the globe westward on its axis till the index has passed over as many hours as the time is past noon; keep the globe from revolving on its axis, find the planets' places on the globe (by Prob. III. or IV.) and if any of their places be above the horizon, such planets will be visible at the given time and place.

EXAMPLES.

1. On the 1st of October, 1821, the longitude of Venus, by the Nautical Almanac, was 7 signs 1° 19′, and latitude 0° 36′ S. was she visible at Washington at 7 o'clock in the evening?

Ans. Venus was a little above the western edge of the horizon, nearly in conjunction with α in Libra.

2. On the 1st of November, 1821, the longitudes and latitudes of the planets were as follows; were any of them visible at New-York at 9 o'clock in the evening?

	LON.	LAT.		LON.	LAT.
☿	8s 2° 9′	2° 51′ S.	♃	0s 23° 22′	1° 33′ S.
♀	8 19 27	2 6 S.	♄	0 22 2	2 47 S.
♂	4 18 24	1 36 N.	♅	9 0 19	0 15 S.
☽'s	9 26 44	2 55 S. at midnight.			

PROBLEM XXVII.

To find how long Venus rises before the sun, when she is a morning star, and how long she sets after the sun, when she is an evening star, on any given day, at any given place.*

RULE.

Elevate the pole for the latitude of the place; then, if Venus be a morning star, bring the sun's place in the ecliptic for the given day to the eastern edge of the horizon, and set the index of the hour circle to 12; turn the globe eastward on its axis till the place of Venus on the globe for the given day (found by Prob. III. or IV.) comes to the eastern edge of the horizon, and the hours passed over by the index will show how long Venus rises before the sun; but, if Venus be an evening star, bring the sun's place to the western edge of the horizon, and set the index to 12; turn the globe westward on its axis till the place of Venus on the globe, comes to the western edge of the horizon, and the hours passed over by the index will show how long Venus sets after the sun.

Note. The same rule will serve for Jupiter, by finding his place on the globe instead of that of Venus.

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*When Venus' longitude is less than the sun's longitude, she rises before him in the morning, and is then called a morning star; but when her longitude is greater than the sun's longitude, she shines in the evening after him, and is then called an evening star.

EXAMPLES.

1. On the 1st of October, 1821, the longitude of Venus was 7 signs 12° 19′, and latitude 0° 36′ S.; and on the same day the sun's longitude was 6 signs 8° 30′, or 8½ degrees in Libra; consequently, Venus was an evening star; how long did she shine after the sun set at Washington?

Ans. Venus shone 1 hour 30 minutes after the sun set.

2. On the 1st of May, 1821, the longitude of Jupiter was 14° 41′ and latitude 1° 7′ S. and of course a morning star; how long did he rise before the sun at Paris?

3. On the 1st of April, 1821, the longitude of Venus was 11 signs 27° 56′, and latitude 1° 29′ S. was she a morning star, and if so, how long did she rise before the sun at Philadelphia?

4. On the 25th of February, 1821, the longitude of Jupiter was 11 signs 29° 10′, and latitude 1° 7′ S. was he an evening star, and if so, how long did he shine after the sun set at Baltimore?

PROBLEM XXVIII.

To find what stars the moon can eclipse, or make a near approach to, or what stars lie in or near her path.

RULE.

Find the moon's longitude and latitude, or her right ascension and declination, for several days together, in the Nautical Almanac, and mark her places on the globe; (by Prob. III. or IV.) then lay the quadrant of altitude over these places, and you will see the moon's orbit, consequently, what stars lie in her path.

EXAMPLES.

1. What stars were in or near the moon's path on the 11th, 12th, 13th, 14th, and 15th of November, 1821? her longitudes and latitudes, at midnight, on these days, being as follows:

LONGITUDES.				LATITUDES.		
11th,	2s	21°	8′	4°	42′	N.
12th,	3	5	39	4	8	N.
13th,	3	19	41	3	19	N.
14th,	4	3	11	2	20	N.
15th,	4	16	14	1	16	N.

Ans. The stars will be found to be δ in Taurus, ϵ in Gemini, γ in Cancer, &c.

2. On the 16th, 17th, 18th, 19th, and 20th of December, 1821, what stars lay in or near the moon's path? her right ascension and declination, at midnight, on these days being as follows:

RIGHT ASCENSION.			DECLINATION.		
16th,	180°	30′	3°	20′	S.
17th,	191	11	8	48	S.
18th,	202	5	13	54	S.
19th,	213	25	18	30	S.
20th,	225	22	22	24	S.

PROBLEM XXIX.

The day of the month being given, to find all those places on the earth to which the moon will be nearly vertical on that day.

RULE

Find the moon's declination in the Nautical Almanac for the given day, and observe whether it be north or south; then, (by the terrestrial globe) mark the moon's declination on that part of the brass meridian which is numbered from the equator towards the poles; turn the globe eastward on its axis, and all places that come under the above mark, will have the moon nearly* vertical on the given day.

EXAMPLES.

1. On the 6th of December, 1821, the moon's declination at midnight was 20° 44′ N. over what places on the earth did she pass nearly vertical?

Ans. The moon was nearly vertical at Surat, Cape Blanco, Mecca, &c.

2. On the 16th of October, 1821, the moon's declination at midnight was 27° 6′ N. over what places did she pass nearly vertical?

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* On account of the swift motion of the moon in her orbit, and consequently, a considerable increase or decrease of declination in the course of 24 hours, the solution will differ materially from the truth.

3. To what places of the earth will the moon be vertical, when she has the greatest* north declination.

4. To what places of the earth will the moon be vertical, when she has the greatest south declination?

PROBLEM XXX.

To find the time of the moon's southing, or coming to the meridian of any place, on any given day.

RULE.

Elevate the pole for the latitude of the place, find the moon's longitude and latitude, or her right ascension and declination, in the Nautical Almanac, for the given day, and mark her place on the globe; bring the sun's place in the ecliptic for the given day to the brass meridian, and set the index of the hour circle to 12; turn the globe westward on its axis till the moon's place comes to the meridian, and the hours passed over by the index will show the time from noon, when the moon comes to the meridian of the place.

Or, *correctly, without the globe.* Take the difference between the sun and moon's increase of right ascension in 24 hours; then, as 24 hours less this difference, are to 24 hours, so is the moon's right ascension at noon, less† the sun's right ascension at the same instant, to the time of the moon's passage over the meridian.

* When the moon's ascending node is in Aries, she will have the greatest north and south declination; for her orbit making an angle of 5¼ degrees with the ecliptic, her greatest declination will be 5¼ degrees more than the greatest declination of the sun.

† If the sun's right ascension be greater than the moon's, 24 hours must be added to the moon's right ascension before you subtract.

EXAMPLES.

1. At what hour on the 5th of November, 1821, did the moon pass over the meridian of Greenwich? the moon's right ascension at noon being 344° 33′ and her declination 5° 29′ S.

Ans. By the globe, the moon came to the meridian at fifteen minutes past 8 o'clock in the evening.

By Calculation.

Sun's right ascension at noon 5th Nov.=	14h.	41′	16″
Do. 6th Nov.=	14	45	15
Increase in 24 hours,	0	3	59

Moon's right ascension at noon 5th Nov. 1821,=	344°	33′
Do. 6th Nov.=	357	19
Increase in 24 hours,	12	46=

51′ 4″, hence, 51′ 4″—3′ 59″ 47′ 5″=to the excess of the moon's motion above the sun's in 24 hours.

Moon's right ascension 344° 33′,=	22h.	58′	12″
Sun's do =	14	41	16
	8	16	56

Then, as 24h.—47′ 5″ : 24h. : : 8h. 16′ 56″ : 8h. 34′ the true time of the moon's passage over the meridian, agreeing with the Nautical Almanac.

2. At what hour, on the 16th of October, 1821, did the moon pass over the meridian of Greenwich; her right ascension being 94° 28′, and her declination 27° 50′ north?

3. At what hour on the 1st of September, 1821, did the moon pass over the meridian of Greenwich; her right ascension being 208° 37′, and declination 16° 31′ south?

4. At what hour, on the 6th of December, 1821; did the moon pass over the meridian of Greenwich; her right ascension being 32° 41′, and declination 18° 8′ north?

MISCELLANEOUS EXAMPLES

EXERCISING THE

PROBLEMS ON THE GLOBES.

1. When it is 8 o'clock in the morning at Paris what is the hour at Washington?

2. What is the sun's longitude and declination on the 17th January?

3. How many miles make a degree of longitude in the latitude of Philadelphia?

4. When the sun is on the meridian of Philadelphia, what places have midnight?

5. What is the angle of position between London and Rome?

6. On what point of the compass must a ship steer from Cape Henry to Cape Clear?

7. What places of the earth have the sun vertical on the 13th of April?

8. What places of the earth are in perpetual darkness on the 18th December? And how far does the sun shine over the south pole?

9. Where does the sun begin to shine constantly without setting on the 9th of May, and in what latitude is he beginning to be totally absent?

10. On what two days of the year will the sun be vertical at Bencoolen?

11. What is the length of the longest day at Washington?

12. What day of the year is of the same length as the 12th of May?

13. In what latitude does the sun set at 11 o'clock on the 1st of June?

14. How many days in the year does the sun rise and set in latitude 76 degrees north?

15. On what two days of the year at Philadelphia, is the time of the sun's rising to the time of his setting in the direct ratio of 4 to 3?

16. What day following the 4th of July is one hour shorter than it, at Baltimore?

17. What is the equation of time dependent on the obliquity of the ecliptic on the 1st of August?

18. On what day of the year is the meridian altitude of the sun at Washington equal to 45 degrees?

19. At what hour will the sun be due east at Philadelphia on the 25th of May?

20. Being at sea on the 14th of June, I found the sun's setting amplitude to be 29 degrees from the west towards the north; required the latitude the ship was in.

21. At what hour in the afternoon on the 2d of August, is the length of the shadow of any object at Washington equal to its height?

22. What is the sun's azimuth at New York on the 30th of April, at 8 o'clock in the morning?

23. Required the duration of twilight at the north pole.

24. When the sun is setting to the inhabitants of Baltimore, to what inhabitants of the earth is he then rising?

25. What inhabitants of the earth have the greatest portion of moon light?

26. Required the latitude and longitude of *Dubhe*, in the back of the Great Bear.

27. What is the altitude of the north polar star at Mexico?

28. What is the hour at Paris, when a cane placed perpendicular to the horizon of Philadelphia on the 10th of June in the afternoon, casts a shadow equal to the length of the cane?

29. On the 25th of August, 1821, the geocentric longitude of Venus was 5 signs 27° 22′, and latitude 1° 4′ north; was she a morning or an evening star? If a morning star, how long did she rise before the sun at Washington; but if an evening star, how long did she shine after the sun set?

30. What inhabitants of the earth have no shadow on the 17th of May, when it is 40 minutes past one o'clock in the afternoon, at Philadelphia?

31. In what latitude is the meridian altitude of *Procyon* 57 degrees above the south point of the horizon?

32. Being at sea in north latitude on the 5th of June, I observed the altitude of *Lyra* to be 49 degrees, and that of *Altair* 21 degrees; required the latitude in, and the hour of the night.

33. What stars never set at Washington, and what stars never rise at the same place?

34. How far northward must a person travel from Baltimore to lose sight of Sirius?

35. On what day of the month, and in what month, will the pointers* of the Great Bear be on the meridian of Washington at 10 o'clock in the evening?

36. When *Lyra* was on the meridian, I observed that *Spica* in Virgo was setting; required the latitude of the place of observation.

37. What is the sun's greatest meridian altitude at Paris?

38. What stars rise acronycally at Washington, on the 11th of February?

39. What stars rise cosmically at Dublin, on the 12th of April?

40. What stars set heliacally at London, on the 4th of July?

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* The two stars, marked α and β in the Great Bear, are called the pointers, because a line drawn through them, points to the polar star in the Little Bear; consequently they will both be on the meridian at the same time.

41. What stars set cosmically at Baltimore, on the 9th of October?

42. On what day of the year does *Aldebaran* rise acronycally at Washington?

43. On what day of the year does *Procyon* begin to be visible in the evening at Washington?

44. On what day of the year does *Sirius* cease to appear in the evening at Baltimore.

45. At what time of the year does *Bellatrix* rise with the sun at New-York?

46. At what time of the year does *Sirius* become visible in the morning at Washington, after having been so near the sun as to be hid by the splendor of his rays?

47. At what time of the year does *Arcturus* first become invisible in the evening at Washington, on account of its nearness to the sun?

48. How long does β in Leo continue above the horizon, during one revolution of the earth on its axis, at Baltimore?

49. What is the distance in degrees between *Regulus* and *Dubhe*?

50. What are the sun's right ascension, oblique ascension, oblique decension, ascensional or decensional difference, rising amplitude, setting amplitude, and the time of his rising and setting at Washington, on the 21st of June?

51. Required the Antœci of New-York.

52. Required the Periœci of Washington.

53. Required the Antipodes of O-why-hee.

54. Required the time of the moon's passage over the meridian of Greenwich, on the 10th of June, 1821; her right ascension being 197° 91′, and declination 11° 1′ south.

55. There is a place in latitude 19° 26′ N. which is 1770 geographical miles from Philadelphia, and west of it; required that place.

56. At what rate per hour are the inhabitants of Baltimore carried by the revolution of the earth on it axis from west to east?

57. What inhabitants of the earth have the days and nights always of equal length?

58. What is the length of the longest day in latitude 75° north?

59. In what latitude north, is the length of the longest day 100 days?

60. On what day of the year does the sun set without rising for several revolutions of the earth on its axis, in latitude 73° north?

61. How many days in the year does the sun rise and set in latitude 81 degrees north?

62. At what time does day break at Dublin, on the morning of the 1st of May?

63. What star has 11 signs 1° 15′ of longitude, and 21° 6′ S. latitude?

64. Being at sea in north latitude, I observed the altitude of *Capella* to be 37° 20′, and that of *Castor* at the same time, 58° 30′ required the latitude in.

65. Describe a horizontal dial for the latitude of Baltimore.

66. In what climate is Edinburgh, and what other places are situated in the same climate?

67. What is the sun's altitude at Washington on the 31st of August, when the sun is setting at London?

68 Describe a vertical dial, facing the south, for the latitude of Washington.

69. In what latitude is the meridian altitude of Cor Hydræ 55 degrees above the south point of the horizon?

70. Required the oblique ascension and descension of β in Leo, and its rising and setting amplitude, at Washington.

71. What is the breadth of the 10th north climate, and what places are situated within it?

72. What is the breadth of the 27th climate, or the 3d within the polar circles?

73. On the 7th of June, 1821, the sun's meridian altitude was observed to be 81° 20′ north of the observer; required the latitude.

74. On the 24th of April in the afternoon, the sun's altitude was observed to be 58° 25′ and after 2¾ hours had elapsed, his altitude was 29° 10′; required the latitude, supposing it to be north.

75. Required the right ascension and declination of β in Lepus.

76. On the 25th of November, when it is 9 o'clock in the evening at Washington, what stars are culminating?

77. On the 1st of May, 1821, the right ascension of Jupiter was 16 degrees, and his declination 4° 46′ north, was he a morning or an evening star? If a morning star, how long did he rise before the sun at Washington; but, if an evening star, how long did he shine after the sun set?

78. What is the meridian altitude of *Rigel* in the left foot of Orion, at Washington?

79. On what point of the compass does *Arcturus* bear at Washington, on the 21st of March, at 9 o'clock in the evening; and what is its altitude?

80. At London on the 18th of October, the star *Capella* was observed to be 31 degrees above the horizon, and east of the meridian; what was the hour at Washington at that time?

81. At what hour of the night at Washington, on the 15th of March, did *Regulus* bear S. E. by E.?

82. At what hour at Washington, on the 7th of December, will *Castor* and *Capella* have the same azimuth?

83. What inhabitants of the earth have noon, when day breaks at Washington on the 17th of January?

84. At what hour at Washington, on the 8th of January, will *Rigel* and *Pollux*, have each 38 degrees of altitude?

85. On the 5th of March, 1821, the moon's declination at midnight was 6° 9′ N. over what places on the earth did she pass nearly vertical?

86 In what latitude does the sun begin to shine constantly without setting, when the inhabitants of Mexico have no shadow at noon?

87. When the inhabitants of London begin to have constant day or twilight, what stars rise heliacally at Washington?

88. When the sun is on the meridian of Washington, at the time of the vernal equinox, what stars are rising at Canton?

89. When the sun sets without rising for several revolutions of the earth on its axis, at the North Cape, at what time does day break at Washington?

90. Are the clocks of Paris faster or slower than those at Washington, and how much?

91. What inhabitants of the earth have the sun vertical, when the *Pleiades* come to the meridian of Ispahan, at 8 o'clock in the evening?

92. What is the moon's longitude when new moon happens on the 24th of November?

93. What is the moon's longitude, when full moon happens on the 11th of September?

94. In what latitude is the length of the longest day, to the length of the shortest, in the ratio of two to one?

95. What is the length of the longest night, where the sun's least meridian altitude is 10 degrees?

96. What is the length of the longest day, where the sun's greatest meridian altitude is 62 degrees?

97. What is the altitude of the sun at Washington, when he is due west on the 10th of June?

98. At what hour does the sun rise at Washington, when twilight begins at Edinburg?

99. When *Aldebaran* rises with the sun at Washington, at what hour will *Altair* culminate at London?

100. Calculate the true time of the moon's passage over the meridian of Greenwich, on the 6th of December, 1821. The moon's right ascension at noon on the 6th of December was 32° 41′ and on the 7th at noon it was 47° 50′. The sun's right ascension at noon, on the 6th of December was 16h. 51′ 2″, and on the 7th at noon it was 16h. 55′ 25″

MISCELLANEOUS QUESTIONS,

DESIGNED FOR THE

EXAMINATION OF THE STUDENT.

1. WHAT is the figure of the earth?
2. Who was the first person that demonstrated the earth to be an *oblate spheroid?*
3. How many miles in diameter is the earth?
4. What is the ratio between the earth's equitorial and polar diameters?
5. What proofs can you give that the earth is spherical?
6. What is the best artificial representation of the earth?
7. In what time does the earth revolve on its axis from west to east?
8. At what rate per hour, are the inhabitants of the equator carried from west to east by the revolution of the earth on its axis?
9. In what time does the earth travel round the sun, and at what rate per hour?
10. What is the distance of the earth from the sun?
11. At what time of the year is the earth nearest to the sun?
12. What is the terrestrial globe?
13. What is the celestial globe?
14. What is the axis of the earth?
15. What are the poles of the earth?

16. What is the brass meridian, and how does it divide the globe?
17. What is a great circle?
18. What is the equator?
19. What are meridians?
20. What is the first meridian?
21. What is the ecliptic?
22. What is the zodiac, and what is its breadth?
23. How are the ecliptic and zodiac divided?
24. What are the northern signs?
25. What are the southern signs?
26. What is the horizon, and what is the distinction between the sensible and rational horizon?
27. What is the wooden horizon, and how is it divided?
28. What are the tropics, and at what distance are they from the equator?
29. What are small circles?
30. What are the polar circles, and where are they situated?
31. What are parallels of latitude?
32. What are the hour circles?
33. What is the hour circle, and how is it divided?
34. What is the mariner's compass, and how is it divided?
35. What is the quadrant of altitude, and how is it divided?
36. What are the cardinal points of the horizon?
37. What are the cardinal points of the heavens?
38. What are the cardinal points of the ecliptic?
39. What is the zenith?
40. What is the nadir?
41. What are the equinoctial points?
42. What are the solstitial points?
43. What is the declination of the sun, a star, or planet?
44. What is the latitude of a place?
45. What is the latitude of a star or planet?

46. What is the pole of a great circle?
47. What is the longitude of a place?
48. What is the longitude of a star or planet?
49. What is the difference of latitude between two places?
50. What is the difference of longitude between two places?
51. What are parallels of celestial latitude?
52. What are the colures?
53. What are azimuth or vertical circles?.
54. What is the altitude of any object in the heavens?
55. What is the azimuth of any object in the heavens?
56. What is the amplitude of any celestial object?
57. What is the zenith distance of any celestial object?
58. What is the polar distance of any celestial object?
59. When is a star or planet said to culminate?
60. What is apparent noon?
61. What is true or mean noon?
62. What is the equation of time and upon what does it depend?
63. What is a true solar day?
64. What is a mean solar day?
65. What is an astronomical day?
66. What is a civil day?
67. What is a siderial day?
68. What is an artificial day?
69. What is a tropical year?
70. What is the siderial year?
71. What do you understand by the precession of the equinoxes?
72. How many different positions of the sphere are there?
73. What is a right sphere, and what inhabitants of the earth have this position?

74. What is a parallel sphere, and what inhabitants of the earth have this position?

75. What is an oblique sphere, and what inhabitants of the earth have this position?

76. What is a zone, and how many are there?

77. Where is the torrid zone situated, and what is its breadth?

78. Where are the two temperate zones situated, and what is the breadth of each?

79. Where are the two frigid zones situated, and what is the extent of each?

80. What is a climate, and how many are there?

81. What inhabitants of the earth are called Antœci to each other?

82 What inhabitants of the earth are called Periœci to each other?

83. What inhabitants of the earth are called Antipodes?

84. What is the right ascension of the sun or a star?

85. What is the oblique ascension of the sun, or a star?

86. What is the oblique descension of the sun, or a star?

87. What is the ascensional or descensional difference?

88. What is twilight, and when does it begin in the morning and end in the evening?

89. What is the angle of position between two places on the globe?

90. What are rhumb-lines?

91. When is a star said to rise and set acronycally?

92. When is a star said to rise and set cosmically?

93. When is a star said to rise and set heliacally?

94. What is a constellation, and what is its use?

95. What are planets?

96. What are primary planets, and how many belong to the solar system?

97. What are secondary planets, and how many are there?

98. What is the orbit of a planet?

99. What are nodes?

100 What is the disc of the sun and moon?

101. What are the geocentric latitudes and longitudes of the planets?

102. What are the heliocentric latitudes and longitudes of the planets?

103. What is the eccentricity of the orbit of a planet?

104. What is the transit of a planet?

105. What are the diurnal and nocturnal arcs described by the heavenly bodies?

106. What is the parallax of any celestial body?

107. What is the elongation of a planet?

108. When are two celestial bodies in conjunction?

109. When are two celestial bodies in opposition?

110. When is a planet's motion said to be direct?

111. When is a planet's motion said to be retrogade?

112. What is Aphelion?

113. What is Perihelion?

114. What is Apogee?

115. What is Perigee?

116. What is the solar system, and in what part of it is the sun situated?

117. In what time does the sun revolve on his axis, and how is it determined?

118. What is the ratio between the magnitude of the sun, and that of the earth?

119. Which is the nearest planet to the sun?

120. What is the distance of Mercury from the sun?

121. In what time does Mercury revolve round the sun?

122. What is the diameter of Mercury?

123. What is the comparitive magnitude between Mercury and the earth?

124. What is the comparison between the light and heat which Mercury receives from the sun, and the light and heat which the earth receives from him?

125. In what time does Venus revolve round the sun?

126. When is Venus a morning star, and when is she an evening star?

127. How long is Venus a morning star?

128. What is the distance of Venus from the sun?

129. What is the magnitude of Venus?

130. What is the comparison between the light and heat which Venus receives from the sun, and the light and heat which the earth receives from him?

131. What is the distance of the moon from the earth?

132. What is the length of the periodical month?

133. What is the length of the synodical month?

134. In what time does the moon revolve on her axis?

135. What is the comparative magnitude between the moon and the earth?

136. How much larger does the earth appear to the moon, than the moon does to us?

137. What is the distance of Mars from the sun?

138. In what time does Mars revolve round the sun, and at what rate per hour?

139. What is the diameter of Mars?

140. What is the magnitude of Mars, when compared with that of the earth?

141. When and by whom was the planet Ceres discovered?

142. What is the diameter of Ceres?

143. In what time does Ceres perform her revolution round the sun?

144. Where is Ceres situated?

145. When was the planet Pallas discovered, and by whom?

146. Where is Pallas situated?

147. When and by whom was the planet Juno discovered?

148. Where is Juno situated?

149. When and by whom was the planet Vesta discovered, and what is its apparent magnitude?

150. Which is the largest of all the planets?

151. What is the distance of Jupiter from the sun?

152. In what time does Jupiter revolve round the sun, and at what rate per hour?

153. What is the comparative magnitude between Jupiter, and the earth?

154. In what time does Jupiter revolve on his axis?

155. How many satellites is Jupiter attended by?

156. Who discovered the satellites of Jupiter?

157. What is the best method yet known of determining the longitudes of places on land?

158. How are the longitudes of places determined by the eclipses of Jupiter's satellites?

159. What is the comparison between the light and heat which Jupiter receives from the sun, and the light and heat which the earth receives from him?

160. What is the distance of Saturn from the sun?

161. In what time does Saturn revolve round the sun, and at what rate per hour?

162. What is the comparative magnitude between Saturn and the earth?

163. In what times does Saturn revolve on its axis?

164. What is the comparison between the light and heat which Saturn receives from the sun, and the light and heat the earth receives from him?

165. How many satellites is Saturn attended by?

166. Who discovered the sixth and seventh satellites of Saturn, and why are they not called the first and second, since they are nearer to Saturn than any of the rest?

167. What is the ring of Saturn, and who discovered it?

168. Who discovered the ring of Saturn to be double?

169. What is the general opinion respecting the nature of the ring of Saturn?

170. When was Herschel discovered, and by whom?

171. What is the distance of Herschel from the sun?

172. In what time does Herschel revolve round the sun?

173. What is the comparative magnitude between Herschel and the earth?

174. How many satellites is Herschel attended by?

175. Who discovered the satellites of Herschel?

176. What are comets, and what is the cause of their tails?

177. What are the fixed stars, and why are they so called?

178. What is the number of fixed stars, which appear to the naked eye in both hemispheres?

179. What is the Milky-way composed of?

180. What is the distance of the nearest fixed star from the earth computed to be?

181. Into how many constellations are the stars divided?

182. How are the stars in each constellation denoted?

183. What is the occasion of an eclipse of the sun?

184. What is the occasion of an eclipse of the moon?

185. Are there not more solar than lunar eclipses, and if so, why are there more visible eclipses of the moon than of the sun?

186. How many degrees does the motion of the moon exceed the apparent motion of the sun in 24 hours?

187. At what hour at Baltimore is the sun due east at the time of the equinoxes?

188. How many degrees must I travel westward from Baltimore, that my watch may be two hours too fast?

189. What inhabitants of the earth have the days and nights always equal, or 12 hours long?

190. When have the inhabitants of north latitude the longest day?

191. When have the inhabitants of south latitude the longest day?

192. When have the inhabitants of north latitude the shortest day?

193. When have the inhabitants of south latitude the shortest day?

194. When are the days and nights equal, or 12 hours each, all over the world?

195. What place has the greatest longitude, the least longitude, no longitude, and every longitude?

196. How many times in the year does the sun rise and set at the north pole?

197. How long does the moon continue without setting, above the horizon at the north pole?

198. How many degrees is the north polar star above the horizon of Baltimore?

199. How far northward must a person travel from Baltimore that the altitude of the north polar star may increase 10 degrees?

200. What is the length of the longest day at all places situated on the Arctic circle?

201. On what two days of the year is the sun vertical at all places situated on the equator?

202. On what day of the year is the sun vertical at all places situated on the Tropic of Cancer?

203. On what day of the year is the sun vertical at all places situated on the Tropic of Capricorn?

204. How many degrees southward must a person travel from Baltimore, that the altitude of the north polar star may decrease 10 degrees?

205. Required the sun's declination, when dark night begins at the north pole.

206. At what rate per hour must a person travel westward on the equator, that it may always be the same hour of the day with him?

207. At what rate per hour must a person travel eastward on the equator, that the length of the day to him may be but six hours?

A TABLE

OF THE

LATITUDES AND LONGITUDE

OF SOME OF THE

PRINCIPAL PLACES IN THE WORLD.

The Longitudes are reckoned from the meridian of Greenwich Observatory.

Names of Places.	*Country or Sea.*	*Latitudes.*	*Longitudes.*
Aberdeen,	Scotland,	57° 9′ N.	2° 8′ W.
Abo,	Sweden,	60 27 N.	22 13 E.
Acapulco,	Mexico,	17 10 N.	101 26 W.
Achen,	Sumatra I.	5 22 N.	95 35 E.
Adrianople	Turkey,	41 10 N.	26 28 E.
Albany,	N. York,	42 39 N.	73 46 W.
Aleppo,	Syria,	36 11 N.	37 10 E.
Alexandretta,	Syria,	36 35 N.	36 15 E.
Alexandria,	Egypt,	31 12 N.	29 55 E.
Alexandria,	Virginia,	38 45 N.	77 16 W.
Algiers,	Africa,	36 49 N.	2 12 E.
Alicant,	Spain,	38 21 N.	0 30 W.
Amboy,	N. Jersey,	40 33 N.	74 20 W.
Amiens,	France,	49 54 N.	2 18 E.
Amsterdam,	Holland,	52 22 N.	4 51 E.
Annapolis,	Maryland,	39 2 N.	76 45 W.
Antigua I.	Carib. Sea,	17 4 N.	62 9 W.
Antioch,	Syria,	35 55 N.	36 15 E.
Archangel,	Russia,	64 34 N.	38 55 E.
Ascension I.	South Atlantic,	7 56 S.	14 21 W.
Athens,	Turkey, Eur.	38 5 N.	23 52 E.
St. Augustine,	East Florida,	29 58 N.	81 40 W.
Babylon, (anc.)	Syria,	33 0 N.	42 46 E.
Bagdad,	Syria,	33 20 N.	44 23 E.
Baltimore,	Maryland,	39 20 N.	76 43 W.
Barcelona,	Spain,	41 26 N.	2 12 E.

Names of Places.	*Country or Sea.*	*Latitudes.*	*Longitudes.*
Basil or Basle,	Switzerland,	47°34′N.	7°35′ E.
Batavia,	Java I.	6 11 S.	106 52 E.
Bayonne,	France,	43 29 N.	1 29 W.
Belfast,	Ireland,	54 43 N.	5 57 W.
Belgrade,	Turkey E.	45 0 N.	21 20 E.
Bencoolen,	Sumatra,	3 49 S.	102 3 E.
Bergen,	Norway,	60 23 N.	5 12 E.
Berlin,	Germany,	52 32 N.	13 23 E.
Bermudas I. N.	Atlantic,	32 35 N.	64 28 W.
Berne,	Switzerland,	46 57 N.	7 26 E.
Bilboa,	Spain,	43 26 N.	2 47 W.
Bologna,	Italy,	44 30 N.	11 21 E.
Bologne,	France,	50 43 N.	1 36 E.
Bombay I.	India, E.	18 56 N.	72 54 E.
Boston,	Massachusetts,	42 23 N.	71 0 W.
Botany Bay,	New Holland,	34 0 S.	151 20 E.
Bourbon I. N.	Indian Ocean,	20 51 S.	55 30 E.
Bordeaux,	France,	44 50 N.	35 W.
Bremen,	Germany,	53 5 N.	8 49 E.
Brest,	France,	48 23 N.	4 30 E.
Bristol,	England,	51 28 N.	2 35 W.
Brunswick,	Germany,	52 25 N.	10 31 E.
Brunswick,	Maine,	43 52 N.	69 59 W.
Brunswick,	New-Jersey,	39 39 N.	74 18 W.
Brussels,	Netherlands,	50 51 N.	4 21 E.
Buenos Ayres,	S. America,	34 35 S.	58 24 W.
Cadiz,	Spain,	36 31 N.	6 17 W.
Cagliari,	Sardinia I.	39 25 N.	9 38 E.
Cairo,	Egypt,	30 3 N.	31 17 E.
Calais,	France,	50 57 N.	1 50 E.
Calcutta,	Bengal,	22 35 N.	88 28 E.
Cambridge,	England,	52 13 N.	5 E.
Cambridge,	Massachusetts,	42 23 N.	71 7 W.
Canary I.	Canary Is.	28 13 N.	15 39 W.
Candi,	Ceylon,	7 45 N.	80 46 E.
Candia,	Candy I.	35 19 N.	25 18 E.
Canton,	China,	23 7 N.	113 16 E.
Cape Clear,	Ireland,	51 18 N.	9 30 W.
— Finisterre,	Spain,	42 53 N.	9 18 W.
— St. Vincent,	Portugal,	37 2 N.	9 2 W.
— Blanco,	Africa,	20 55 N.	17 10 W.
— Verd,	do.	14 47 N.	17 33 W.
— Siera Leon,	do.	8 30 N.	13 9 W.
— Good Hope,	do.	34 29 S.	18 23 E.

Names of Places.	*Country or Sea.*	*Latitudes.*	*Longitudes.*
Cape Comorin,	Hindoostan,	8° 4′N.	77°34′ E.
— Cod, (light)	Massachusetts,	42 5 N.	70 14 W.
— Charles,	Virginia,	37 12 N.	76 9 W.
— Hatteras,	N. Carolina,	35 12 N.	75 5 W.
— Horn,	S. America,	55 58 S.	67 26 W.
— Blanco,	Peru,	3 45 S.	83 0 W.
— Farewell,	Greenland,	59 38 N.	42 42 W.
— Henry,	Virginia,	36 57 N.	76 19 W.
— May,	New-Jersey,	39 4 N.	74 54 W.
Carthagena,	Spain,	37 37 N.	1 1 W.
Carthagena,	Terra Firma,	10 26 N.	75 21 W.
Charleston,	South Carolina	32 50 N.	80 1 W.
Christiana,	Norway,	59 55 N.	10 48 E.
Conception,	S. America,	36 43 S.	73 6 W.
Constantinople,	Turkey,	41 1 N.	28 55 E.
Copenhagen,	Denmark,	55 41 N.	12 35 E.
Corinth,	Turkey,	37 54 N.	22 54 E.
Cork,	Ireland,	51 54 N.	8 28 W.
Cracow,	Poland,	50 11 N.	19 50 E.
Cusco,	Peru,	12 25 N.	73 35 W.
Damascus,	Syria,	33 16 N.	36 20 E.
Dardanelles,	Turkey,	30 10 N.	26 26 E.
St. Domingo,	Hispaniola,	18 20 N.	69 46 W.
Douglas,	Isle of Man,	54 7 N.	4 38 W.
Dover,	England,	51 8 N.	1 19 E.
Dresden,	Germany	51 3 N.	13 41 E.
Drontheim,	Norway,	63 23 N.	10 22 E.
Dublin,	Ireland,	53 22 N.	6 17 W.
East Cape,	New Zealand,	37 44 S.	178 58 E.
Eddystone light,	England,	50 7 N.	4 25 W.
Edinburgh,	Scotland,	55 57 N.	3 12 W.
Exeter,	England,	50 44 N.	3 34 W.
False Cape,	Delaware,	38 38 N.	75 9 W.
Fayettville,	N. Carolina,	35 11 N.	78 50 W.
Fez,	Africa,	33 31 N.	5 0 W.
Florence,	Italy,	43 46 N.	11 2 E.
France, I.	Indian Ocean,	20 27 N.	57 15 E.
Francford on the Main,	Germany,	50 8 N.	8 35 E.
Funchal,	Madeira,	32 38 N.	16 56 W.
Galway,	Ireland,	53 10 N.	10 1 W.
Geneva,	Switzerland,	46 12 N.	6 8 E
Genoa,	Italy,	44 25 N.	8 50 E
Georgetown,	Columbia dist.	38 55 N.	77 14 W

Names of Places.	*Country or Sea.*	*Latitudes.*	*Longitudes.*
St. George's town,	Bermudas I.	32° 22′ N.	64° 33′ W.
Ghent,	Netherlands,	51 3 N.	3 43 E.
Gibraltar,	Spain,	36 5 N.	5 4 W.
Glasgow,	Scotland,	55 52 N.	4 15 W.
Goa,	Malabar,	15 28 N.	73 59 E.
Gottenburg,	Sweden,	57 42 N.	11 57 E.
Gottingen (ob.)	Germany,	51 32 N.	9 54 E.
Greenwich (ob.)	England,	51 28⅔ N.	0 0
Guadaloupe,	West-Indies,	15 59 N.	61 59 W.
Hague,	Holland,	52 4 N.	4 17 E.
Halifax,	Nova Scotia,	44 44 N.	63 36 W.
Hamburg,	Germany,	53 34 N.	9 54 E.
Hanghoo,	China,	30 25 N.	120 12 E.
Hanover,	Germany,	52 22 N.	5 49 E.
Hartford,	Connecticut,	41 50 N.	72 35 W.
Havana,	Cuba I.	23 12 N.	82 18 W.
Havre de Grace	France,	49 29 N.	0 6 E.
St. Helena, James town,	Atlantic,	15 55 S.	5 49 W.
Hervey's I.	Society Isles,	19 17 S.	158 56 W.
Holyhead,	Wales,	53 23 N.	4 45 W.
Hull,	England,	53 48 N.	33 W.
Jackson (Port)	New-Holland,	33 52 S.	151 14 E.
Jaffa,	Syria,	32 5 N.	10 E.
St. Jago,	Cuba I.	19 55 N.	75 35 W.
Ice Cape,	Nova Zembla,	75 30 N.	67 30 E.
Jeddo,	Japan Is.	36 30 N.	140 0 E.
Jersey I. St. Aubins,	English Channel,	49 13 N.	2 12 W.
Jerusalem,	Syria,	31 45 N.	35 20 E.
St. John's,	Newfoundland,	47 32 N.	52 26 W.
Ispahan,	Persia,	32 25 N.	52 50 E.
Isthmus of Darien joins North and South America.			
Isthmus of Suez joins Africa to Asia.			
Kamtschatka,	Siberia,	56 30 N.	161 0 E.
Kilkenny,	Ireland,	52 37 N.	7 15 W.
Kingston,	Jamaica I.	18 15 N.	76 44 W.
Kinsale,	Ireland,	51 32 N.	8 38 W.
Koningsberg,	Prussia,	54 43 N.	21 35 E.
Lancaster,	England,	54 4 N.	2 50 E.
Lancaster,	Pennsylvania,	40 3 N.	76 20 W.
Lands End,	England,	50 6 N.	5 54 W.
Leghorn,	Italy,	43 33 N.	10 16 E.
Lexington,	Kentucky,	37 59 N.	84 46 W.
Leyden,	United Provinces,	52 8 N.	4 28 E.
Lima,	Peru,	12 2 S.	76 50 W.

Names of Places.	*Country or Sea.*	*Latitudes.*	*Longitudes.*
Limerick,	Ireland,	52° 33′ N.	8° 42′ W.
Lisbon,	Portugal,	38 42 N.	9 9 W.
Liverpool,	England,	53 22 N.	2 57 W.
Lizard,	England,	49 57 N.	5 13 W.
London,	England,	51 31 N.	6 W.
Londonderry,	Ireland,	54 59 N.	7 15 W.
Lyons,	France,	45 46 N.	4 49 E.
Madeira I. Funchal,	Atlantic,	32 38 N.	16 56 W.
Madras,	India,	13 [illegible] N.	80 25 E.
Madrid,	Spain,	40 25 N.	3 38 W.
Majorca I.	Miditerranean,	39 35 N.	2 30 E.
Malacca,	E. India,	2 12 N.	102 9 E.
Malta I.	Mediterranéan,	35 54 N.	14 28 E.
Marietta,	Ohio,	39 8 N.	81 38 W.
Marseilles,	France,	43 18 N.	5 22 E.
Martinico, I. Fort Royal,	W. Indies,	14 36 N.	61 10 W.
Mecca,	Arabia,	21 45 N.	40 15 E.
Mexico,	N. America,	19 54 N.	100 7 W.
Milan,	Italy,	45 28 N.	9 14 E.
Minorca, Port Mahon,	Mediterranean,	39 51 N.	3 54 E.
Montpelier,	France,	43 37 N.	3 52 E.
Montreal,	Canada,	45 33 N.	73 18 W.
Morocco,	Barbary,	31 0 N.	7 4 W.
Moscow,	Russia,	55 45 N.	37 46 E.
Nankin,	China,	32 5 N.	118 46 E.
Nantes,	France,	47 13 N.	1 34 W.
Nantucket,	Nantucket I.	41 18 N.	70 10 W.
Naples,	Italy,	40 50 N.	14 17 E.
Newcastle,	England,	55 3 N.	1 30 W.
New-Orleans,	Louisiana,	29 58 N.	90 6 W.
New-York,	New York,	40 42 N.	74 1 W.
Niagara,	New York,	43 16 N.	79 0 W.
Norfolk,	Virginia,	36 55 N.	76 22 W.
North Cape,	Lapland,	71 30 N.	25 49 E.
Oporto,	Portugal,	41 10 N.	8 27 W.
L'Orient, (port)	France,	47 45 N.	3 22 E.
Otaheite,	S. Pacific Ocean,	17 20 S.	149 30 W.
Owhyhee,	do.	18 54 N.	155 48 W.
Palermo,	Sicily I.	38 7 N.	13 35 E.
Palmyra,	Arabia,	33 58 N.	38 42 E.
Panama,	Mexico,	8 58 N.	80 15 W.
Paris, (obs.)	France,	48 50 N.	2 20 E.

Names of Places.	*Country or Sea.*	*Latitudes.*	*Longitudes.*
Pekin, (obs.)	China,	39°54′N.	116°27′ E.
Pensacola,	W. Florida,	30 30 N.	87 10 W.
Petersburg,	Russia,	59 56 N.	30 18 E.
Philadelphia,	Pennsylvania,	39 57 N.	75 14 W.
Pico I.	Azores,	38 27 N.	28 28 W.
Pittsburg,	Pennsylvania,	40 26 N.	80 0 W.
Pondicherry,	East India,	11 56 N.	79 52 E.
Portland,	Maine,	43 39 N.	70 28 W.
Porto Bello,	Terra Firma,	9 33 N.	79 50 W.
Port Royal,	Jamaica,	18 0 N.	76 45 W.
Portsmouth,	England,	50 47 N.	1 6 W.
Potosi,	Peru,	20 0 S.	66 15 W:
Prague,	Bohemia,	50 6 N.	14 24 E.
Presburg,	Hungary,	48 8 N.	17 10 E.
Quebec,	Canada,	46 48 N.	71 6 W.
Quito,	Peru,	13 S.	78 10 W.
Rhodes,	Rhodes I.	35 27 N.	28 45 E.
Richmond,	Virginia,	37 35 N.	77 43 W.
Riga,	Russia,	56 55 N.	24 0 E.
Rio Janeiro,	Brazil,	22 54 S.	42 44 W.
Rochelle,	France,	46 9 N.	1 10 W.
Rochester,	England,	51 26 N.	30 E.
Rome (St. Pet.)	Italy,	41 54 N.	12 28 E.
Rotterdam,	United Prov.	51 56 N.	4 28 E.
Rouen,	France,	49 27 N.	1 5 W.
Salonica,	Turkey,	40 41 N.	23 7 E.
Samarcand,	W. Tartary,	39 35 N.	64 20 E.
Santa Cruz,	Teneriffe I.	28 39 N.	16 22 W.
Santa Fee,	New Mexico,	36 54 N.	104 30 W.
Savannah,	Georgia,	32 4 N.	81 11 W.
Siam,	E. India,	14 18 N.	100 49 E.
Smyrna,	Natolia,	38 28 N.	27 7 E.
Stockholm,	Sweden,	59 21 N.	18 4 E.
Suez,	Egypt,	29 50 N.	33 27 E.
Surrinam,	S. America,	6 30 N.	55 30 W.
Syracuse,	Sicily I.	36 53 N.	15 17 E.
Teneriffe Peak,	Canary I.	28 15 N.	16 45 W.
Tobolsk,	Siberia,	58 12 N.	68 19 E.
Tornea,	Lapland,	65 51 N.	24 14 E.
Toulon,	France,	43 7 N.	5 55 E.
Toulouse,	France,	43 46 N.	1 26 E.
Trent,	Germany,	46 5 N.	11 6 E.
Trenton,	New Jersey,	40 13 N.	74 50 W.
Trincomale,	Ceylon I.	8 33 N.	81 21 E.

Names of Places.	*Country or Sea.*	*Latitudes.*	*Longitudes.*
Tripoli,	Barbary,	32°54′N.	13°20′ E.
Tunis,	Barbary,	36 16 N.	10 40 E.
Turin,	Italy,	45 5 N.	7 39 E.
Upsal,	Sweden,	59 52 N.	17 43 E.
Utretcht,	United Prov.	52 5 N.	5 9 E.
Venice,	Italy,	45 27 N.	12 4 E.
Vera Cruz,	Mexico,	19 10 N.	97 20 W.
Versailles,	France,	48 48 N.	2 7 E.
Vienna (obs.)	Austria,	48 12 N.	16 22 E.
Warsaw,	Poland,	52 16 N.	21 3 E.
Washington,	N. America,	38 53 N.	77 13 W.
Waterford,	Ireland,	52 12 N.	7 6 W.
Wexford,	Ireland,	52 20 N.	6 24 W.
Wyburg,	Russia,	60 55 N.	30 20 E.
York,	England,	53 58 N.	1 7 W.
York Town,	Virginia,	37 14 N.	76 36 W.
Zurich,	Switzerland,	47 22 N.	8 32 E.
Zutphen,	United Prov.	52 12 N.	6 15 E..

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